Fish Springs National Wildlife Refuge
Vegetation Mapping Project

2011-2014

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PROJECT TEAM ACKNOWLEGMENTS

This project could not have been completed without substantial regional support and extensive work by the Fish Springs NWR staff, including a number of temporary biological technicians and volunteers.

2011 - Pilot Year (Shoveler and Pintail units)

A National Vegetation Classification (NVC) mapping project funding proposal was submitted to the regional I&M program and approved for $23,397 in funds to cover additional staff and supply costs. Due to the lateness of receiving the funds, a contract was established with Brigham Young University (BYU) to secure employment of mapping technicians in 2012 and 2013. Project design and implementation for field data collection methods was led by the refuge manager using GIS technical advice as provided by HAPET biologist Sean Fields, and also later in the process by new I&M GIS manager JoAnn Dullum. Sean and JoAnn also provided all GIS staff training, direction in GIS application, and ongoing technical support. The NVC "alliance" information was obtained through the efforts of the GIS manager and the refuge manager. Additional mapping personnel included Tyrell Orme, GS-05 biological technician (field crew sub-lead), and biological volunteers Bromwyn Maier, Nathan Waid, and Bryanne Colver. Tasha Dolgoff, wildlife refuge specialist, when not at extensive law enforcement training, provided volunteer recruitment, mapping crew leadership, and GIS support.

2012 - Major Mapping Year (90% of Refuge initially mapped)

A second NVC mapping project funding proposal was submitted to the regional I&M program and approved for $30,724 in funds to cover additional staff and supply costs. The contract established with BYU in 2011 provided additional personnel support. Tasha Dolgoff, wildlife refuge specialist, provided volunteer recruitment before her departure for a fulltime law enforcement officer position. All field and office mapping efforts were led by Ryan Haffelle, GS-07 biological technician, under the supervision of the refuge manager, with GIS staff training and support provided by Sean Fields and JoAnn Dullum. Mapping personnel included Nathan Waid, GS-05 biological technician (sub-lead to Ryan), Melissa Smith, BYU contract technician, and biological volunteers John Bourne, Ellen Pero, Michelle Watkins, and Emily Keifer. Due to the departure of Ryan Haffelle three months into the project for fulltime career employment in South Dakota, further crew lead was provided by Nathan Waid, as supervised by the refuge manager. John Bourne was promoted to a GS-5 biological technician and a third GS-5 biological technician, Tiffany Cummins, was hired to round out the mapping team for the remainder of the year.

2013/14 - Mapping finalization (including verification and accuracy assessment)

In November 2012, Tiffany Cummins was hired as a full-time wildlife biologist for the Refuge and she assumed project lead to continue all field and office mapping work in 2013. Sean and JoAnn provided limited GIS support when needed. Mapping personnel included John Bourne and Julie Long, GS-05 biological technicians, Melissa Smith and Carly Russell, BYU contracted technicians, and biological volunteers Nick Jenson, Mackenzie Brown, and Elizabeth Tray.

2014 – Additional mapping products

A concept of mapping classification categories for broad habitat types and water regimes was developed by the refuge manager in order to create mapping products useful to HMP development and future habitat management. The refuge biologist provided GIS expertise in producing these mapping products. Julie Long, GS-05 biological technician, contributed substantially to digitizing needs.

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EXECUTIVE SUMMARY

Fish Springs National Wildlife Refuge (Refuge) is a 17,992-acre refuge located within the Great Salt Lake Desert, UT. Within the Refuge, vegetation habitats range from arid scrub uplands to diverse spring fed wetland habitats (USFWS 2004). In the early 1960's an impoundment and water delivery system was developed within the wetlands of the Refuge. This system provides a high degree of water control in meeting many of the desired biological outcomes of habitat management.

A Habitat Management Plan (HMP) is currently being developed for the Refuge. This plan is stepped-down from the previously completed Comprehensive Conservation Plan (CCP) and will help guide Refuge management decisions and actions for the next 15 years. In support of HMP development, Refuge staff began assessing historical baselines and current conditions of both habitats and wildlife populations. Within this process, critical information gaps were identified and the need for a current Refuge-wide vegetation map was identified. Between May 2011 and August 2014, vegetation mapping was completed, as compliant with Service policy (620 FW 1 and 701 FW 2) and HMP development guidelines (Exhibit 1, 620 FW 1), to the National Vegetation Classification Standard (Standard or NVC).

The NVC provides a standardized hierarchical approach to classifying vegetation and this standard is being implemented by federal, state, tribal, and non-profit organizations throughout the United States. In order to maximize the efficiency and usefulness of the Refuge's mapping project in support of management needs, mapping was completed to the NVC Alliance level (dominant species).

Mapping took place in the following 8 stages:

1) Site visits were conducted and 16 NVC Alliances* that best fit dominate vegetation cover at Fish Springs NWR were selected;
2) 14 Project Codes (PCs) were defined to meet management's mapping needs in conditions that do not meet a published NVC Alliance;
3) Prior to heading into the field, an initial digitization effort was completed where recognizable stands of dominant vegetation were digitized using a 2006 NAIP aerial image;
4) The initial digitizing effort was improved upon through a ground-truthing process in the field using established mapping standards and diagnostic criteria;
5) Once all vegetation mapping across the Refuge was completed, a re-verification effort in the field was conducted, and corrections were made where needed;
6) A digital editing review was completed to identify any potential digital mapping errors, and if needed sites were revisited;
7) A stratified random sampling method was utilized to assess map accuracy, and any identified errors were corrected;
8) The baseline NVC vegetation map (alliance level) was then utilized to create additional classification categories of broader habitat types and water regimes.

Of the available 30 mapping categories (Alliances and PCs) established for the mapping effort, 28 were utilized within the final NVC vegetation map.

A total of 819 randomly selected assessment points were visited for the final accuracy assessment, resulting in a final map accuracy of 96.7%.

** All selected published Alliances are described within the 'International Vegetation Classification Alliances and Associations Occurring in Nevada with Proposed Additions' report (Peterson 2008).*

I. INTRODUCTION

Justification

On October 1997, President Clinton signed into effect the National Wildlife Refuge System Improvement Act (Public Law 105-57) (Act) to ensure that the Refuge System is managed as a national system of related lands, water, and interests for the protection and conservation of our Nation's wildlife resources. One of the Act's main components is a requirement for preparing a Comprehensive Conservation Plan (CCP) for each refuge. A CCP describes the desired future conditions of a refuge or planning unit; provides long-range guidance and management direction to achieve the purposes of the refuge; helps fulfill the mission of the Refuge System; maintains and, where appropriate, restores the ecological integrity of each refuge and the Refuge System; helps achieve the goals of the National Wilderness Preservation System; and meets other mandates.

In September 2004, Fish Springs NWR (Refuge) completed its CCP, which placed priority on habitat management and directed that a Habitat Management Plan (HMP) be developed to provide greater detail for implementing action under its general concepts (USFWS 2004). Beginning in 2011, in support of HMP development, Refuge staff began to determine the status of current and historical baselines for vegetation and wildlife uses. As a result of this process, critical information gaps were identified and Refuge staff determined that a current Refuge-wide vegetation map to the dominant species level was needed. The last dominate species vegetation map completed for the Refuge was in 1959 by H. Tietjen, when the Refuge was first established (Tietjen 1959), whereas broader vegetation community classifications were used by the CCP.

Beginning in 2011, Refuge staff began a vegetation mapping project utilizing the National Vegetation Classification Standard (NVC) as compliant with Service policy (620 FW 1 and 701 FW 2) and HMP development guidelines (Exhibit 1, 620 FW 1). The NVC provides a standardized hierarchical approach to classifying vegetation and this standard is being implemented by federal, state, tribal, and non-profit organizations throughout the United States.

The Refuge's NVC mapping project involved the use of Geographic Information Systems (GIS) technology to create a geospatially represented dominant vegetation coverage map for all 17,992-acres that comprise Fish Springs NWR (Figure 1). The Refuge's NVC vegetation map provides an essential habitat baseline and foundation for the development and implementation of the HMP, especially concerning emphasis in the CCP for implementing actions in support of the Service's Biological Integrity, Diversity, and Environmental Health (BIDEH) policy.

The NVC vegetation map additionally provides for a means of quantitative assessment in vegetation changes since the creation of the Refuge and its impoundment system, as well as possible future injury to habitats through offsite ground water depletion affecting the Refuge's spring flows and water rights.

The NVC vegetation map also provides a baseline for the creation of mapping classification categories of broader habitat types and water regimes useful to habitat management, as these mapping classifications will better inform the development process of Refuge's HMP and Inventory and Monitoring (I&M) program.

Background

Fish Springs National Wildlife Refuge (NWR), Utah, is comprised of 17,992 acres featuring unique artesian spring flows in an otherwise arid, desert landscape. Its primary habitat features in support of wildlife include a variety of brackish to saline wetlands. The Refuge is positioned within a valley at the eastern base of the Fish Springs Mountain Range of the Basin and Range Physiographic Province, as well as the hydrologically-defined, internally-drained Great Basin, the former lakebed of historic Lake Bonneville, and along the southern extreme of the current-day Great Salt Lake Desert.

In the early 1960's, a water impoundment and delivery system was constructed within the Refuge's wetlands to enhance capability in migratory bird management. This system provided refuge managers the ability to efficiently move and manage water with a high degree of control through use of gravity flows among the managed units. As a result, major shifts initially occurred in water regimes and vegetation composition relative to the native marsh. However, as within the native marsh, perennial vegetation within the managed wetland system continued to be dominant on the landscape and highly stabilized over time. This stability was provided by long-term continued use of prescribed optimum water levels in water management. Acknowledging this long-term dominance and stability of perennial vegetation in our habitats is highly important, as our Refuge mapping efforts in the field spanned three years and the base imagery used was from 2008.

II. NVC VEGETATION MAPPING METHODS

NVC Vegetation Mapping Standards and Diagnostic Criteria

The National Vegetation Classification Standard (hereon Standard or NVC) is a standardized classification methodology consisting of a hierarchical list of vegetation types and descriptions (FGDC 2008). The NVC provides a framework for consistent national vegetation classification in order to allow for uniform statistics, quantification and comparisons of vegetation resources across the United States. This Standard was developed and is maintained by the United States Federal Geographic Data Committee (FGDC). The original version of NVC was created by the FDGC Vegetation Subcommittee in 1997. The Standard has since been updated by the committee in 2008 to the current NVC version and includes a cross walk from the original 1997 classification hierarchy consisting of seven hierarchy levels to the final 8 hierarchy levels found within the 2008 version (FDGC 2008).

The eight levels within the 2008 NVC hierarchy are tiered into three tier groups: Upper, Middle, and Lower (Table 1). The upper and mid-tiers are made up of the upper six physiognomic levels and while the lower tier is made up of the lower two floristic layers. The category "Group" is the lowest level of the Middle tier and identifies differences at the regional level. The lowest tier is comprised of the Alliance and Association floristic levels.

Figure 1. Refuge and project boundary for NVC vegetation mapping effort at Fish Springs NWR.

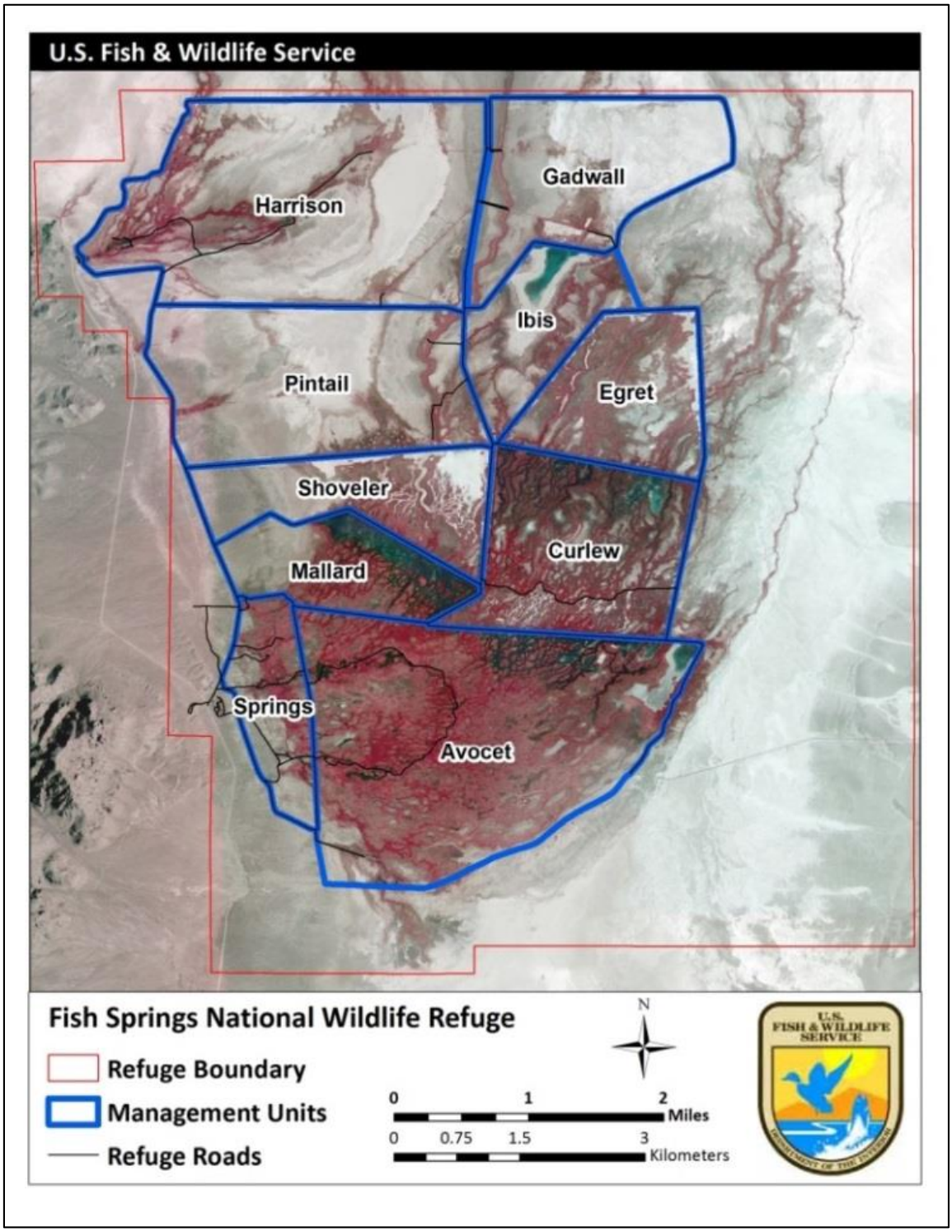


Table 1. **National Vegetation Classification Standard Hierarchy (FGDC 2008).**

Tier		Level	
Upper	(*Physiognomic-Ecological*)	Level 1	Formation Class
		Level 2	Formation Subclass
		Level 3	Formation
Mid	(P*hysiognomic-Floristic*)	Level 4	Division
		Level 5	Macrogroup
		Level 6	Group
Lower	(*Florisitic*)	Level 7	Alliance
		Level 8	Association

The Standard is to be followed by all Federal agencies for vegetation classification data collected directly or indirectly using federal funds (FDGC 2008) and as compliant with Service policy (620 FW 1 and 701 FW 2) and HMP development guidelines (Exhibit 1, 620 FW 1). The Standard should be applied at the level of the hierarchy appropriate to meet agency needs (FDGC 2008). For this NVC mapping project, vegetation was mapped to the Alliance level as its identification factors best matches the lowest level at which Refuge management decisions and actions will occur.

The vegetation hierarchy is based on diagnostic growth forms and species, and compositional similarity. These are species and growth forms that exhibit patterns of relative fidelity, constancy, or dominance that differentiate one type from another (FDGC 2008). At the lower floristic levels, emphasis is placed on differential and dominant species and compositional similarity in combination with specific physiognomic and habitat conditions (FDGC 2008).

Lower-level floristic units (FDGC 2008):

> **Alliance:** A vegetation classification unit of low rank (7th level) containing one or more associations, and defined by a characteristic range of species composition, habitat conditions, physiognomy, and diagnostic species, typically at least one of which is found in the uppermost dominant strata of the vegetation. Alliances reflect regional to subregional climate, substrates, hydrology, moisture/nutrient factors, and disturbance regimes.
>
> **Association:** A vegetation classification unit of low rank (8th level) defined on the basis of a characteristic range of species composition, diagnostic species occurrence, habitat conditions and physiognomy. Associations reflect topo-edaphic climate, substrates, hydrology, and disturbance factors.

The Standards' diagnostic criteria used to define vegetation units (in our case the Alliance level or dominant species) are to be clearly stated and the range of variation in composition, habitat, and physiognomy and structure should be clearly described. All vegetation units of this mapping project are categories of existing, or actual, natural and semi-natural vegetation.

Diagnostic growth forms and species for the Alliance level are defined as follows (FDGC 2008):

> **Dominance:** The extent to which a given taxon or growth form has a strong influence in a community because of its size, abundance, or cover.
>
> **Dominant Growth Form:** A growth form with a high percent cover, usually in the uppermost dominant layer.

Dominant Species: A species with a high percent cover, usually in the uppermost dominant layer (in other contexts dominant species can be defined in terms of biomass, density, height, coverage, etc.)

Refuge NVC Vegetation Mapping Project Criteria

This section describes the diagnostic criteria used for the NVC mapping project on the Refuge, as completed at the Alliance level. As outlined in the NVC Standard for the Alliance level (FGDC 2008), we utilized the following diagnostic emphasis for criteria selection:

Compositional similarity in combination with specific conditions for:

Habitat: a general term referring to the locality, site and particular type of local environment occupied by an organism or community.

Community: a group of organisms linked together by their effects on one another and their responses to the environment they share.

Physiognomy: the visible structure our outward appearance of a plant community as expressed by the dominant growth forms.

Dominant Species: A species with a high percent cover, usually in the uppermost dominant layer (in other contexts dominant species can be defined in terms of biomass, density, height, coverage, etc.)

First, we defined the highly varied habitat types across the Refuge by categories of broad habitat types having compositional similarity with specific conditions, including: Emergent Wetland, Wet Meadow, Wet Shrubland, and Dry-mesic Shrubland. For each of these habitat categories, other diagnostic criteria and a minimum size for vegetation mapping units (minimum mapping unit) were established specific to their conditions. Among the habitat categories, data collection methods also varied by equipment used. Specifically, data was collected primarily while on foot in habitats with relatively small patch sizes and a small minimum mapping unit, and primarily by off-road vehicles or all-terrain vehicles in habitats with relatively large patch sizes and a large minimum mapping unit.

These broad habitat categories are also highly useful to Refuge habitat and water management and planning. Alternatively, NVC classification categories above the Alliance level do not provide a similar level of utility for management and planning needs for the Refuge and therefore were not used. Each Federal agency is free to develop vegetation classification systems that meet their own information and business needs (FGDC 2008). The ecological characteristics of such local vegetation types can help guide the design of map legends (sets of map units) to address varying land management issues at multiple spatial scales (FGDC 2008). The NVC is expected to provide a common link to compare and relate these various map legends to each other and facilitate information sharing between federal agencies and other organizations (FGDC 2008).

<u>Emergent Wetlands</u>

Emergent wetlands include all areas of the native marsh with extreme channel braiding dominated by emergent wetland plant species, as well as expanses of artificially flooded wetland areas. This mapping area encompasses small natural island-plateaus intermixed among a myriad of native channel braids that can contain emergent, wet meadow, or wet shrub species. Due to extreme heterogeneity

and small patch sizes within this area, and distinctly recognizable mono-dominant stands of emergent vegetation and island habitats, this specific habitat category was used in combination with diagnostic criteria that would provide a high degree of mapping accuracy on a relatively small spatial scale.

Minimum Mapping Unit - A patch size of 1 by 2 meters, as made possible with 1-m resolution in the NAIP imagery.

Dominant Species Determination – Mapping units (polygons) were to accurately depict recognizable dominant plant stands based on discernable boundaries as best mapped to the colors represented on NAIP imagery. Emergent plant species typically exist in mono-dominant stands, but where discernable patches support mixed or other plant species, the patch was classified by the upper layer of herbaceous plant species with the highest proportion of cover within the patch. Shrub species could only compose under 10 percent cover within the patch.

Data Collection Methods – Because of the high degree of detail to be captured, and more limited accessibility, emergent marsh areas were largely searched and mapped by personnel on foot.

Wet Meadow

Wet meadow plant species most typically exist in large patches located between emergent marsh and wet shrub dominated communities. Patches of wet meadow are also most often composed of mixed species, but with discernable boundaries and presence of a dominant species. Smaller stands of wet meadow located on island plateaus within emergent marsh were mapped using the protocol outlined for emergent marsh, as described above.

Minimum Mapping Unit – A patch size of 1 by 2 meters, but large patch sizes are most typical.

Dominant Species Determination – Mapping units (polygons) were to accurately depict recognizable dominant plant stands based on discernable boundaries as best mapped to the colors represented on the NAIP imagery. The dominant plant was to be determined by identifying a plant species within the upper strata that composed the highest proportion of cover within the patch. Emergent or shrub species could only be present when under 10 percent cover within the patch.

Data Collection Methods – Because of larger patch sizes, wet meadow areas were most often searched and mapped by personnel operating off-road utility or all-terrain vehicles.

Wet Shrubland

Wet shrub species typically exist in relatively large stands located between wet meadow and dry-mesic upland shrub communities, with discernable boundaries and a dominant shrub species. Except when mixed with *Phagmites australis*, they represent the uppermost dominant strata over other herbaceous species occurring within the stand.

Minimum Mapping Unit – A patch size of 30 m diameter, with 10 percent or greater cover of shrub species where the dominant shrub species composition is wet shrub.

Dominant Species Determination – Mapping units (polygons) were to accurately depict recognizable dominant plant stands based on discernable boundaries as best mapped to the colors represented on NAIP imagery. The dominant plant was to be determined by identifying the wet shrub species with the highest proportion of cover within the patch when using the minimum mapping unit criteria.

Data Collection Methods – Because of larger patch sizes, wet shrub areas were largely searched and mapped by personnel operating off-road utility or all-terrain vehicles.

Dry-Mesic Shrubland

Dry-mesic shrubland areas exist almost exclusively in large stands located between wet shrub dominated communities and bare rock faces and outcroppings of the Fish Springs Range. As opposed to wet meadow, the presence of *Phragmites australis* is highly uncommon, and shrub species represent the uppermost dominant strata in this habitat type.

Minimum Mapping Unit – A patch size of 30 m diameter, with 10 percent or greater cover of shrub species where the dominant shrub species composition is dry-mesic shrub.

Dominant Species Determination – Mapping polygons were to accurately depict recognizable dominant plant stands based on discernable boundaries as best mapped to the colors represented on the NAIP imagery. The dominant plant was to be determined by identifying the dry-mesic shrub species with the highest proportion of cover within the patch when using the minimum mapping unit criteria.

Data Collection Methods – Because of larger patch sizes, dry-mesic shrubland areas were largely searched and mapped by personnel operating off-road utility or all-terrain vehicles when the terrain allowed such use.

Exceptions included special mapping unit classifications for *Phragmites australis*, as highly accurate acreage calculations of this species were deemed important to habitat management planning, regardless of its percent cover within a given stand. However, given that *Phagmites* exists as the uppermost strata in all mixed species stand types, it meets that level of diagnostic criteria as a dominant species within many stands. Additionally, *Phragmites* exists on the Refuge in two forms: sparse and dense (refer to Bolen 1964 for a full description). Dense stands are almost exclusively mono-dominant. Sparse *Phragmites* most often exists in mixed stands with other species that in some instances would otherwise be dominant, such as greasewood, which is also deemed important to habitat management planning. As such, any patch size above the minimum mapping criteria that contained *Phragmites* was mapped using the following mapping unit classifications: Dense Phragmites, Sparse Phragmites, or Phragmites-Greasewood. These special mapping unit classifications allow for more accurate NVC vegetation map representation and acreage estimates needed for these species.

Base Imagery and Pre-Digitization

The base image for the NVC mapping project was a National Agriculture Imagery Program (NAIP) image. A NAIP image is a natural color, Red/Blue/Green (RBG) image that includes a fourth infrared band. These 1-m resolution aerial images are captured by the U.S. Department of Agriculture (USDA) during the agriculture growing season on days with less than 10% cloud cover per quarter quad (USDA 2008).

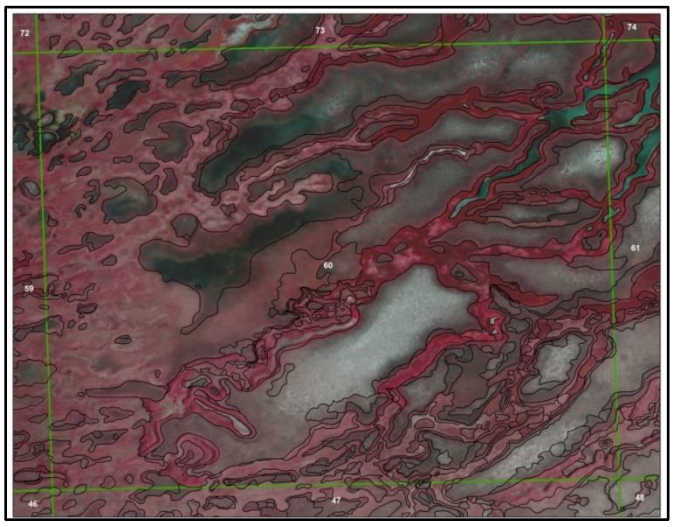
Utilizing this imagery assured that we would be using an image that was taken when the local vegetation was 'leaf-on', or non-dormant. This helps to emphasize the vegetation type and boundaries. The two most recent NAIP images available to us were from 2006 and 2011. However, the 2011 image substantially lacked the quality of the 2006 image in its usefulness for discriminating vegetation types and boundaries, so we selected the 2006 NAIP to serve as our underlying image.

Initially in 2011, we experimented with an automated segmentation program to pre-digitize plant cover into representable mapping units for stands of vegetation that could be classified to dominant species.

Even when tried at varied resolutions, the program was not found to be adequately effective given the high degree of heterogeneity that exists within Refuge wetlands. Alternatively, we employed a manual pre-digitizing method that entailed a person to review and interpret distinct and discernable color variations on the 2006 NAIP image to be pre-digitized into polygons within ArcMap 9.3.1. These pre-digitized polygons represented individual stands of dominant plant species on a base layer that would become the final NVC map once ground-truthed for accuracy in the field and edited within the base layer. Additionally, the boundaries of islands in wetland areas were also included as land features that would be used to assist water regime mapping (see Section IV).

To efficiently and effectively accomplish this, a numbered 102-acre grid was created and placed over the entire pre-digitizing map in order to separate the mapping area into defined and manageable field assignments (Figure-2). The pre-digitized map was then loaded onto a Trimble GPS Unit and accessed using ArcPad 7.1.1. to be used for navigation and accurate orientation in the field.

Figure-2: Example of 2006 NAIP imagery with pre-digitization complete and reference numbered grid present. The black lines show the pre-digitized polygons.



On-the-Ground Data Collection

A list of dominant plant species (Alliances or PCs) was created where each was assigned a specific alpha code. Prior to heading into the field, each mapper was assigned a numbered grid section(s) from the base map, which was printed in color on 11" x 17" paper copy.

While in the field, the mapper would use a Trimble unit to locate their assigned grid area(s) and become oriented for data recording. The paper copy of each field assignment was used to identify and assess pre-digitized polygons and to record accurate field data. This included identifying and recording by alpha code the dominant plant species for each pre-digitized polygon, and adjusting the boundaries of each polygon as warranted.

Whenever possible, the mapper finished their assigned grid(s) within a day. If that was not possible, the mapper would complete it the first thing the next morning. Once a grid(s) was completed the mapper immediately returned to the office to digitize the vegetation polygons in order to maximize accuracy.

NVC Vegetation Mapping Classification – Alliances and Project Codes

The NVC alliances encompass vegetation classifications, but for not submerged vegetation or other non-vegetation habitat features such as water, bare soil, or rock outcroppings. The publication, *International Vegetation Classification Alliances and Associations Occurring in Nevada with Proposed Editions* (Peterson 2008), was utilized for our NVC mapping project as Nevada was the closest state with similar geological and ecological features that had a published alliance list at the time of our mapping project.

An existing Refuge vegetation list was utilized in conjunction with published alliances (Peterson 2008) to generate a list of Refuge-specific alliances for use in our NVC mapping project. Published alliances within Peterson (2008) were found to represent conditions of the Refuge with some differences in underlying geological features, plant community composition, and/or water regimes. The NVC mapping project list of alliances and their total acreages can be found in the results section, Table 2. Detailed alliance descriptions can be located in Appendix 1.

In the process of generating the alliance list, it was determined that circumstances existed in which published alliance descriptions were not available or suitable to meet the management needs of our NVC mapping project. As such, a Project Code (PC) was utilized as a special mapping unit within the NVC mapping project that met the following circumstances:

1) A published alliance (Peterson 2008) was not available or did not adequately match the dominate vegetation present;

2) Alliances were combined into one type of mapping unit when distinguishing between similar species was not deemed important to management needs, and accurate identification of involved species would prove too difficult or time consuming for efficient staff use; and

3) Areas within the Refuge lacked the presence of a natural or semi-natural plant species meeting NVC diagnostic criteria for dominant vegetation.

The non-vegetative PCs (item 3) were utilized to prevent unexplained 'holes' within the NVC vegetation map. The final list of PCs and their total acreages within the Refuge can be found in the Results section, Table 2. Detailed PC descriptions can be located in Appendix 2.

ArcMap GIS NVC Vegetation Mapping / On-screen Digitizing

<u>ArcMap and the RLGIS Toolbar</u>

In an effort to develop standards and guidelines for the collection of spatial data within and across Regions of the USFWS, the Refuge Lands Geographic Information Systems (RLGIS) toolbar was created (USFWS 2007). This toolbar works within the ArcMap environment and utilizes a relational geodatabase (.gdb) format. The current version of RLGIS is comprised of 5 geodatabases; the 'Features Units Monitoring', 'FWS Cadastral', 'Land Cover Habitat', 'Resource Management' and the RLGIS Lookup' geodatabases. The RLGIS toolbar allows the user to interface with these geodatabases as needed within an ArcGIS or ArcPad environment.

The 'Land Cover Habitat' geodatabase's 'Vegetation Cover' feature class is the repository for our Dominate Vegetation mapping efforts. The 'Vegetation Cover' feature class delineates vegetation cover type using the established NVC hierarchical vegetation classification system. Using the RLGIS's toolbar 'List Editor' tool we were able to create a list of established Alliances and PCs. This list was

then available under the established 'Floristic Information', 'Alliance' dropdown menu within the 'Attribute Editor' tool. This tool also allowed us to populate other established fields such as the 'Origin' (i.e. who created or last edited the polygon) and 'Observation Date' for the selected polygon feature. Fields that were auto-populated using a default setting (i.e. the mapper did not manually populate these fields from a menu) setting were required fields such as the 'Station's Organizational Code', 'State', 'Region' and 'Organization Name'. All of the above information was recorded for every polygon that was created, whether it was mapped by hand or mapped using real-time data collection via a Trimble unit. ArcMap 9.3.1 was utilized for all on-screen mapping efforts.

Field Re-Verification Process

Once all initial mapping was completed a field re-verification process was conducted to ensure as accurate a final product as possible. The field re-verification process entailed a mapper revisiting each grid and doing a walkthrough. During the walkthrough the mapper was to look for any patches that should have been mapped that were not, as well as any incorrectly mapped or labeled polygons. In order to successfully compare mapped dominate vegetation to actual vegetation coverage present, the mapper had with them a printed paper map that showed all currently digitized polygons, a printed version of the underlying NAIP image within that grid as well as Trimble GPS unit that had both of those layers loaded onto it for reference. The digitized polygons were all labeled and each mapping category was in a unique color. In some cases, on the ground knowledge provided by the refuge manager helped identify key areas within a grid that needed to be revisited. These areas were given special attention by the mapper assigned to that grid. Any errors identified by the mapper during their walkthrough were mapped on the paper image of the underlying NAIP image and were digitized within the ArcMap 'Vegetation Coverage' feature layer as soon as the grid walkthrough was completed.

Initial Digital Clean-Up

Due to the complexity and high detail of our mapping efforts, as well and the number of individuals who work on the mapping effort, prior to performing our field accuracy assessment a digital editing review of completed. This effort consisted of a systematic review of all grids to ensure proper digitization. This review effort focused on identifying obvious errors such as polygons that crossed multiple grids that were not attributed the same by all mappers, null-slivers resulting from digitizing errors, features that were not sufficiently mapped to the reflect the imagery below, as well as polygons that were not properly attributed. Any discrepancies found were addressed using the original paper map or, when needed, a site visit was conducted to the site in question. All observed errors were corrected prior to an accuracy assessment being completed. To support future development of both the habitat and water regime maps, desert salt grass was broken into two sub-categories: flooded and non-flooded. Initial delineation was done during the field mapping stage when any patch that was raised from the surrounding area was mapped as its own polygon; even if it had the same dominate vegetation cover type. This was further enhanced in the office using a combination of 'on-the-ground' knowledge in combination with color delineation using a series of NAIP images (2006, 2009 and 2011) to sub-divide desert salt grass polygons so that flooded "edges" could be attributed separately from the mail polygon itself. No changes were made to the initial dominate vegetation cover-type attribute. The polygons are distinguished using the "habitat", "water regime" and "plant indicator status" attributes that were added upon completion of the NVC vegetation map.

Accuracy Assessment

In August of 2013, after the completion of the re-verification process and the initial digitizing clean-up, an accuracy assessment was completed to determine how successful our methodology was at representing what dominate vegetation coverage is actually present on the Refuge. Due to the large amount of area to cover, the accuracy assessment was completed in two 2 stages (Figure 3). The 2 stages consisted of a northern and a southern assessment block. For this assessment, the Refuge was divided into a northern half and a southern half where the division did not follow management unit boundaries, but was instead a distinct E-W line dividing the two sections. This dividing line was digitized within ArcMap and a clipping feature was done to break the currently digitized 'Vegetation Coverage' feature layer into northern and southern section. This allowed us to clearly work with only the polygons within the appropriate section for the purpose of the analysis.

Stage One - Northern

Stage one involved creating a centroid point for each polygon that existed within the northern section of the Refuge. These centroid points had the same mapping classification type as the polygon they represented and were assigned a unique point ID. From within each mapping classification type, 20 points were randomly selected to represent that mapping classification type. If a total of 20 points were not available for a given mapping classification type, then all available points were visited. Once the selection process was completed, a total of 369 points were selected for the northern section.

Once the points were selected, they were loaded onto a Trimble GPS unit along with the current 'Vegetation Coverage' feature layer. The points were then divided groups depending upon their spatial location on the Refuge and the groups were then assigned to a mapper to go visit. For the visit, the mapper would take with them the Trimble Unit loaded with the layers mentioned above as well as a paper printout of the underlying image for each selected accuracy point. Once in the field, the mapper would navigate to the assigned point, making sure that they were zoomed in close to the point location within the Trimble unit. This last part was important as some polygons were very small and it helped ensure that the mapper was within the polygon they were sent out to assess. Once they were sure they were as close to the correct location as the accuracy of the Trimble would allow, they would then look to see if they vegetation at and around the point they were standing at was identified to the correct vegetation mapping category. They would then identify whether or not the polygon was labeled correctly. If the polygon was not mapped correctly, they would then choose between three options to describe the error: completely wrong, co-dominate, or identified category type nearby but not at point. A short description of what was observed in the field was also provided in the comments section on the data sheet. Next they used the Trimble unit to navigate around the digitized edge to see if it was mapped correctly. If an edge needed to be corrected, they would make a note within the comments that the polygon needed to be revisited and the edge corrected. All noted errors were then compiled and reviewed by the project leader, after review all errors were corrected prior to moving on to Stage 2 of the accuracy assessment.

Stage Two - Southern

The steps outlined in 'Stage One' were replicated for 'Stage Two' of the accuracy assessment. As more mapping category types were located within the southern portion of the Refuge, a total of 450 accuracy assessment points were created for 'Stage Two'.

III. NVC VEGETATION MAPPING RESULTS

NVC Vegetation Mapping Classification – Alliances and Project Codes

At the end of the mapping effort, a total of 30 mapping categories were available for selection – 16 Alliances and 14 PCs (Appendix 1 and 2). Of these, a total of 28 mapping units were utilized (Table-2). The two mapping categories not utilized were alkali cordgrass (*Spartina gracilis)* and cheat grass (*Bromus tectorum*). The fact they were not utilized is due to lack of occurrence as dominant cover and does not indicate that they are not present on the landscape.

A total of 17877.88-acres were mapped. Allenrolfea and black greasewood were the predominate vegetation dominate cover types found Refuge-wide; covering 32.82% (5866.71-acres) and 10.14% (1813.28-acres) of the mapped area respectively (Table-2). Playa was the most predominate non-vegetation cover type at 10.25% (1833.07-acres) followed by open water at 8.77% (1567.74-acres). These numbers are representative of a specific vegetation type only, not habitat type. The final NVC vegetation map is displayed in Figure-4.

NVC Vegetation Mapping Accuracy

A total of 819 sites (Figure 3) were visited with a final map accuracy of 96.7% meeting the 85.0% criteria. All of the vegetated mapping categories also met the pre-established criteria of 80.0% with the lowest percent accuracy for any vegetation category being 'cattail flooded herbaceous' at 92.3%. Of the four non-vegetated categories, the only one to not meet 100% was 'barren rockface' at 75.0%. This value is skewed due to the small sample size of 4 (Appendix 4). In all, this was not enough of a concern to pull the mapping category. The average percent accuracy across all mapping categories was 96.5%. The final NVC vegetation map can be seen in Figure-4.

The overall differences in our mapped and observed results were found to be not significantly different (P = 0.6322, 2-tailed Wilcoxon matched-pairs signed-ranks test). Of the 27 accuracy assessment sites that were found to be mapped or labeled incorrectly, three (11.1%) had edges that were mapped incorrectly, one was completely wrong (both label and edge were both incorrect), six (22.2%) had the indicated vegetation nearby (<3m) but not at the point, and the remaining 18 (66.7%) were mislabeled but the boundaries were correct for the corrected mapping category (Appendix-4). The 18 mapping label errors resulted from three error sources: misidentification in the field, using the incorrect mapping label in the field, as a result of being entered incorrectly using the RLGIS toolbar when the polygon was digitized or some combination thereof.

It is important to note the accuracy assessment was completed using 26 of the 30 final mapping categories. This resulted from there only being 28 mapping categories prior to the accuracy assessment, with two of the original 28 categories not being present as a dominate vegetation cover. The additional two categories were added post-assessment when the PCs 'disturbed' and 'rabbitbrush' were each split into two separate categories. This was done to allow for a finer scale resolution for these mapping categories and while allowing for the two PCs to be expanded into one PC and three published Alliance mapping categories: 'disturbed' (PC), '*Halogeton glomeratus* Semi-natural Herbaceous Vegetation Alliance' (B.009), '*Ericameria nauseosa* Shrubland Alliance' (A.835), and '*Chrysothamnus albidus* Shrubland Alliance' (A.834) which took the place of the original 'rabbitbrush' category. The polygons that were labeled using the original two PCs were revisited and if needed their label was updated to the new category. A breakdown of the accuracy assessment can be found in Appendix-4.

Figure-3. Location of the 819 accuracy assessment points used assesses the mapping accuracy of the Fish Springs NWR vegetation map.

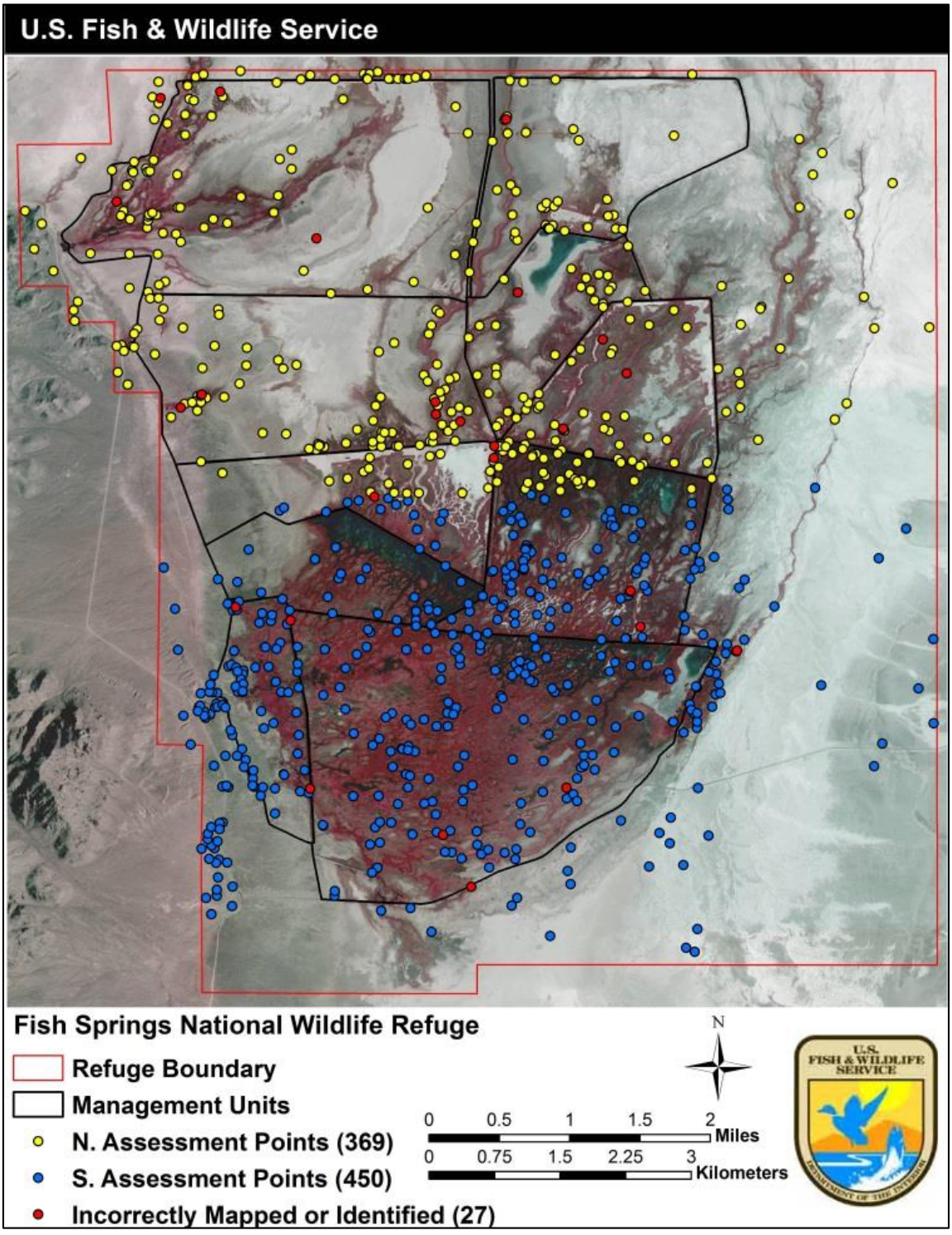
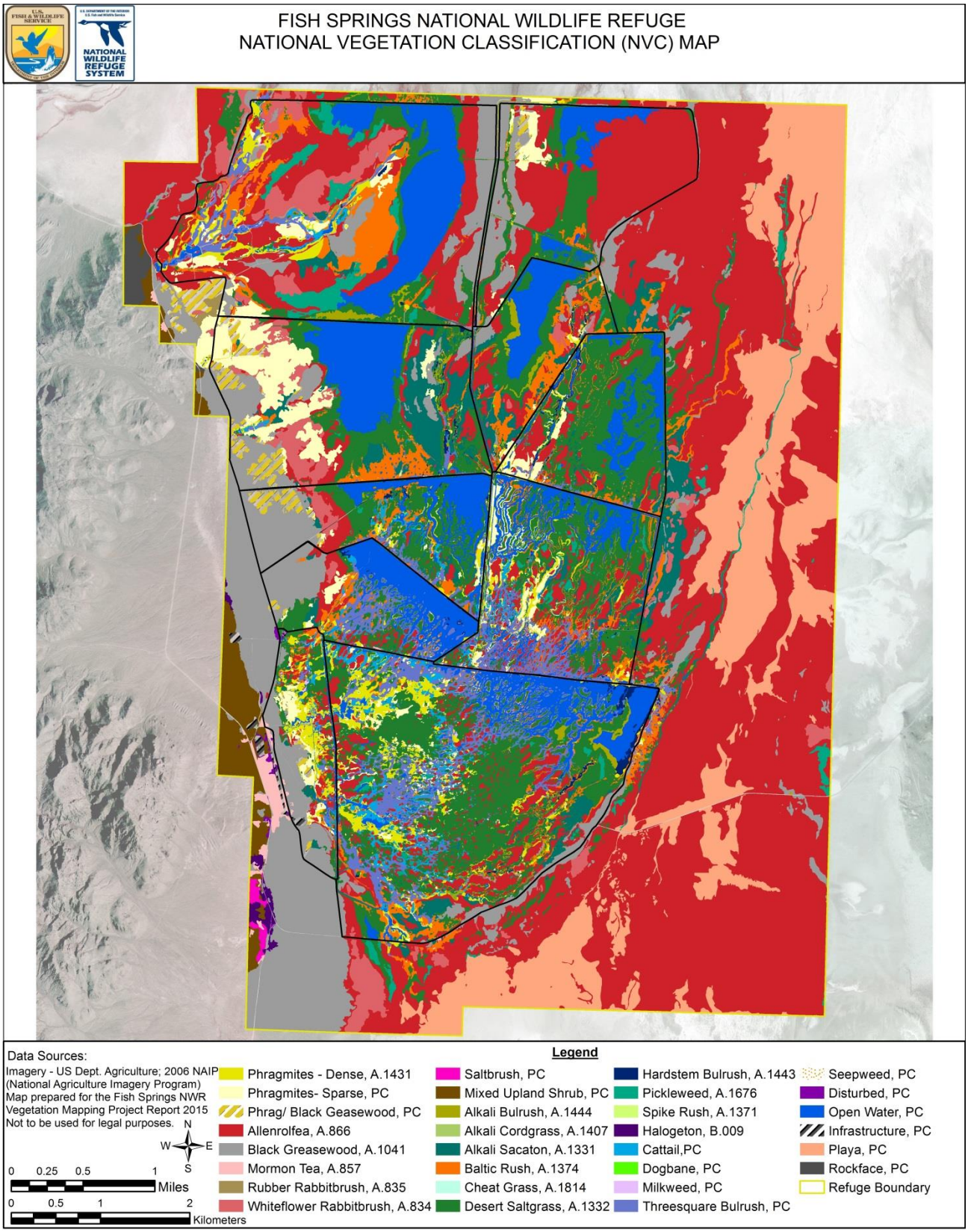


Table-2. NVC mapping classification categories by total acres and percent of total area (Refuge-wide).

NVC Mapping Category/Unit		NVC Alliance/ Project Code		Total Acres	% Area
Phragmites-Dense	*Phragmites australis*	Alliance - A.1431	Herbaceous	363.08	2.03%
Phragmites-Sparse	*Phragmites australis*	Project Code	Herbaceous	521.90	2.92%
Phrag/Black Greasewood	Sarcobatus vermiculatus	Project Code	Herb/Woody	165.53	0.93%
Allenrolfea	*Allenrolfea occidentalis*	Alliance - A.866	Woody	5866.71	32.82%
Black Greasewood	Sarcobatus vermiculatus	Alliance - A.1041	Woody	1813.28	10.14%
Mormon Tea	*Ephedra nevadensis*	Alliance - A.857	Woody	52.69	0.29%
Rubber Rabbitbrush	*Ericameria nauseosa*	Alliance - A.835	Woody	13.73	0.08%
Whiteflower Rabbitbrush	*Chrysothamnus albidus*	Alliance - A.834	Woody	419.80	2.35%
Saltbrush Shrubland	*Atroplex spp.*	Project Code	Woody	16.40	0.09%
Mixed Upland Shrubland	Equal mix of woody spp.*	Project Code	Woody	228.79	1.28%
Alkali Bulrush	*Schoenoplectus maritimus,* also known as *Scirpus paludosus A. Nels* ***	Alliance - A.1444	Herbaceous	81.23	0.45%
Alkali Sacaton	*Sporobolus airoides* (Torr.)	Alliance - A.1331	Herbaceous	567.70	3.18%
Baltic Rush	*Juncus balticus* Willd., also known as *Juncus arcticus Willd.,* var *montanus* Engelm. ***	Alliance - A.1374	Herbaceous	711.98	3.98%
Desert Salt Grass (Flooded)	*Distichlis spicata*	Alliance - A.1332	Herbaceous	1166.69	6.53%
Desert Salt Grass (Non-flooded)	*Distichlis spicata*	Alliance - A.1332	Herbaceous	1351.98	7.56%
Hardstem Bulrush	*Schoenoplectus acutus*, also known as *Scirpus acutus* Muhl.	Alliance - A.1443	Herbaceous	54.96	0.31%
Pickleweed	*Sarcocornia utahensis,* also known as *Salicornia pacifica, Sarcocornia pacifica (Standl.) A.J. Scott var. utahensis (Tidestr.) Munz****	Alliance - A.1676	Herbaceous	229.50	1.28%
Spike Rush	*Eleocharis rostellata* Torr.	Alliance - A.1371	Herbaceous	1.18	0.01%
Halogeton	*Halogeton glomeratus*	Alliance - B.009**	Herbaceous	30.75	0.17%
Cattail	*Typha spp.*	Project Code	Herbaceous	163.70	0.92%
Dogbane	*Apocynum cannabinum* L., also known as Apocynum sibiricum Jacq.*	Project Code	Herbaceous	0.98	0.01%
Milkweed	*Asclepias* spp.*	Project Code	Herbaceous	15.28	0.09%
Threesquare Bulrush	*Schoenoplectus spp.,* also known as *Scirpus spp.**	Project Code	Herbaceous	559.79	3.13%
Seepweed	Suaeda spp.*	Project Code	Herbaceous	0.59	0.00%
Disturbed	Non-native/invasive spp.	Project Code	Herbaceous	8.73	0.05%
Open Water/SAV	N/A	Project Code	Non-Vegetative	1567.74	8.77%
Playa	N/A	Project Code	Non-Vegetative	1833.07	10.25%
Infrastructure	N/A	Project Code	Non-Vegetative	18.98	0.11%
Barren Rockface	N/A	Project Code	Non-Vegetative	51.14	0.29%

**A list of all species included within this PC can be found in Appendix 2.*
***Alliance B.009 is a proposed Alliance within Peterson 2008.*
**** (USDA, NRCS 2014)*

Figure-4. NVC Vegetation Map for Fish Springs NWR. *Classified at the alliance level (dominant species of vegetation), including use of "Project Codes" for combined vegetation alliances and other non-NVC landscape features.*



IV. NVC VEGETATION MAP UTILIZATION

Creation of Habitat and Water Regime Maps

Upon finalization of the NVC vegetation map, additional mapping classification categories were created to generate special mapping units of water regime and broad habitat types across the Refuge, as these mapping classifications are highly useful to Refuge habitat and water management actions and planning. Each Federal agency is free to develop vegetation classification systems that meet their own information and business needs (FGDC 2008). The ecological characteristics of such local vegetation types can help guide the design of map legends (sets of map units) to address varying land management issues at multiple spatial scales (FGDC 2008).

The NVC is expected to provide a common link to compare and relate these various map legends to each other and facilitate information sharing between federal agencies and other organizations (FGDC 2008). Alternatively, NVC classification categories above the Alliance level, as well as available National Wetland Inventory (NWI) mapping products for the Refuge, do not provide a similar level of utility for management and planning needs for the Refuge and therefore were not used for this purpose.

Similarly for wetland habitats in Utah, the Utah Geological Survey developed a simplified functional reclassification of the NWI (and crosswalk) for universal use within the state (Emerson 2014). The wetland mapping categories used by Refuge staff are more detailed and can be easily crosswalked for inclusion into the statewide wetland mapping effort in Utah.

To create 'Habitat' and 'Water Regime' maps, each mapping unit (individual polygon) of the NVC vegetation map was assigned one of various mapping classification subcategories for 'Habitat' and 'Water Regime' categories (see directly below, Figures 5, 6, and 7, and Table-3). The basis of diagnostic criteria used for the creation of these classification categories included collective use of wetland plant indicator status (Lichvar, 2014), NWI water regime definitions (Cowardin 1979), specific water management strategies by area (USFWS 1991; USFWS in progress), and Refuge staff local knowledge.

Hierarchical Mapping Classification for 'Habitat' and 'Water Regime' Categories:

'Habitat'	'Water Regime'
Marsh/Open Water	Permanently Flooded emergent submergent Semi-permanently Flooded emergent (includes flood-tolerant grasses) submergent Seasonally Flooded emergent (includes flood-tolerant grasses) submergent
Wet Meadow	Saturated/Intermittently Flooded
Wet Shrubland	Saturated/Intermittently Flooded *(High Water Table)

Playa	Saturated/Intermittently Flooded
Dry-Mesic Shrubland	*(Upland)
Barren Rock Face	*(Upland)
Disturbed	*varies*
Infastructure	*not applicable*

*Not defined as NWI water regime categories (Cowadin 1979)

For the alliances of *Distichlis spicata* (Desert Salt Grass), *Phagmites australis* (Phragmites dense/sparse), and *Sarcocornia utahensis* (Utah Swampfire/Glasswort) , more than one subcategory under 'Habitat' and 'Water Regime' mapping categories were used, due to each species widespread presence within varied site conditions and water management strategy prescriptions across the Refuge. Desert Salt Grass, for example, is highly flood tolerant and exists within emergent wetland areas that are designated as semi-permanently or seasonally flooded, and it is also of widespread occurrence within wet meadow areas that are seasonally saturated or intermittently flooded.

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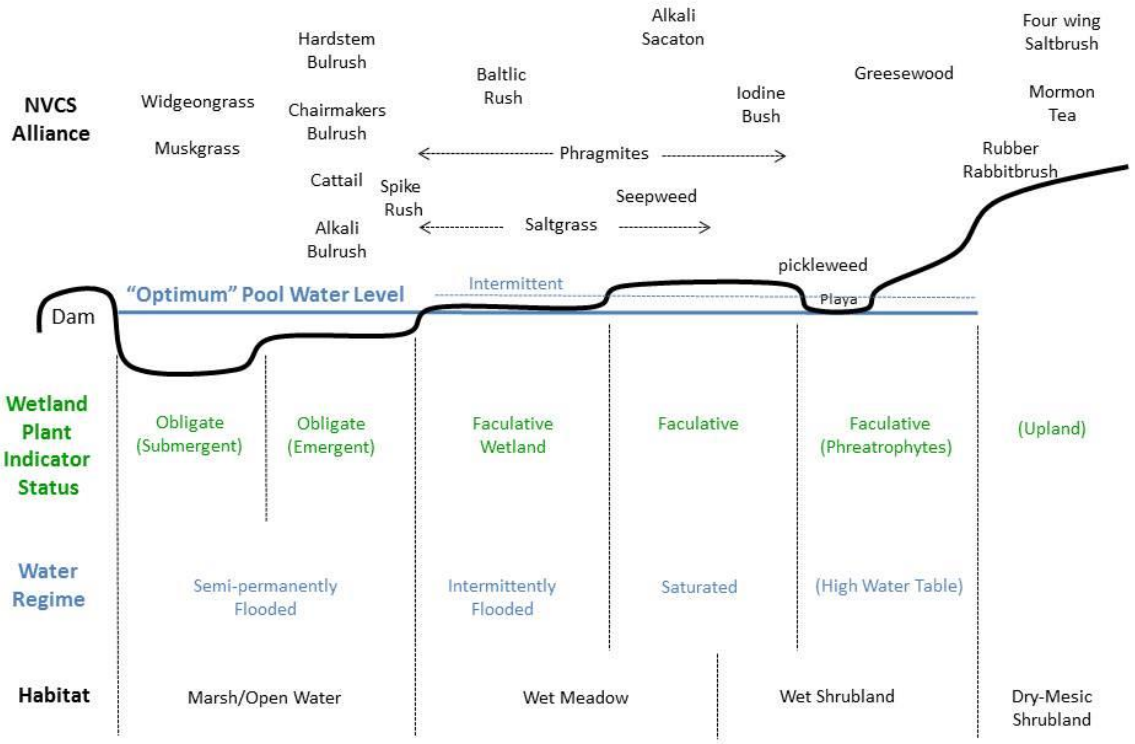
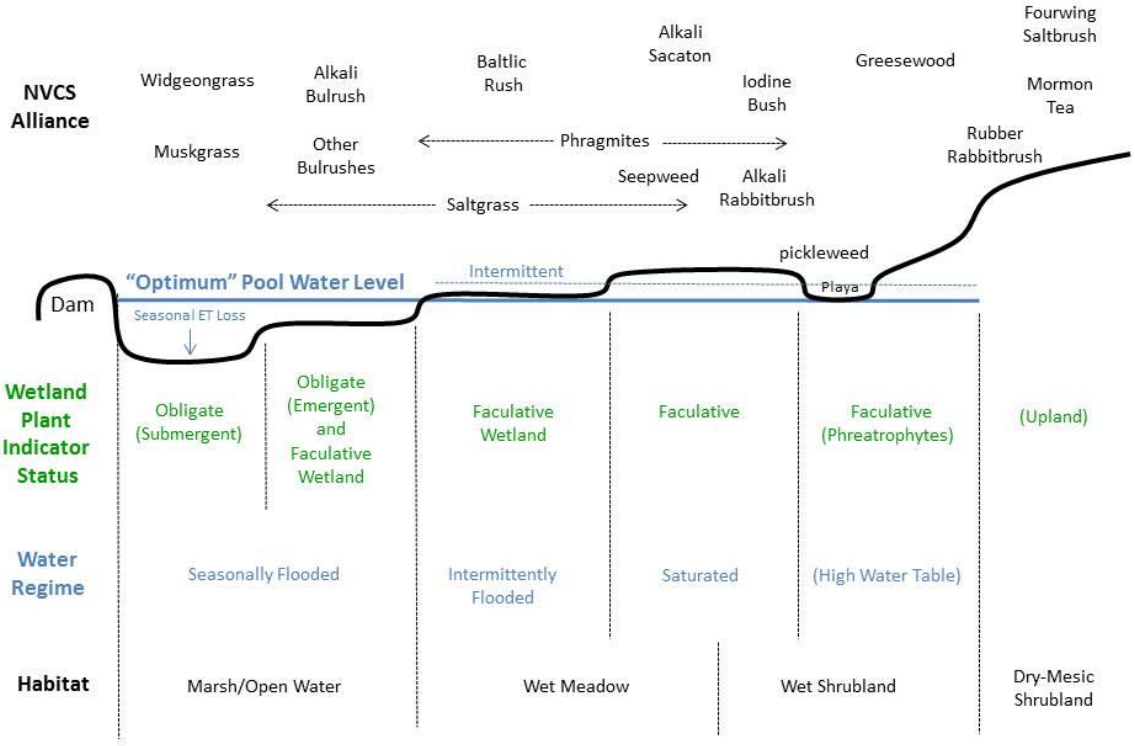
Figures-5. Conceptual relationships of 'Habitat' and 'Water Regime' classifications.



Cross-section: Semi-permanently Flooded Management Areas



Cross-section: Seasonally Flooded Management Areas

The habitat and water regime maps are displayed in Figures 6 and 7, respectively. Three habitat classifications comprised 87.29% (15623.61-acres) of the mapped area (Table-4). These were comprised of wetland shrub at 44.39% (7935.42-acres), marsh/open water at 23.04% (4118.69 acres) and wet meadow at 9.97% (3569.49-acres). Of the water regime classifications, saturated/intermittently flooded comprised 61.19% (10,939.37-acres) of the mapped area. The seasonally flooded, semipermanently flooded, and permanently flooded water regimes made up 16.21% (2897.70-acres), 6.52% (1166.44-acres) and 0.31% (54.56-acres), respectively. More than one water regime classification was applied to individual NVC or habitat mapping classifications (mapping units) depending on site-specific water management strategy prescriptions and other site conditions (Table-3).

Table-3. NVC mapping classification categories by Habitat and Water Regime classification.

NVC Mapping Classification Category/Unit	Alliance/ Project Code	Habitat	Water Regime
Phragmites-Dense	Alliance - A.1431	Wet Meadow Marsh / Open Water	Semipermanently Flooded, Seasonally Flooded, Saturated/Intermittently Flooded
Phragmites-Sparse	Project Code	Wet Meadow Marsh / Open Water	Semipermanently Flooded, Seasonally Flooded, Saturated/Intermittently Flooded
Phrag/Black Greasewood	Project Code	Wet Shrubland	(High Water Table)
Allenrolfea	Alliance - A.866	Wet Shrubland	Saturated/Intermittently Flooded
Black Greasewood	Alliance - A.1041	Wet Shrubland	High Water Table
Mormon Tea	Alliance - A.857	Dry-Mesic Shrubland	(Upland)
Rubber Rabbitbrush	Alliance - A.835	Dry-Mesic Shrubland	(Upland)
Whiteflower Rabbitbrush	Alliance - A.834	Wet Shrubland	(High Water Table)
Saltbrush	Project Code	Dry-Mesic Shrubland	(Upland)
Mixed Upland Shrub	Project Code	Dry-Mesic Shrubland	(Upland)
Alkali Bulrush	Alliance - A.1444	Marsh / Open Water	Semipermanently Flooded **or** Seasonally Flooded
Alkali Sacaton	Alliance - A.1331	Wet Meadow	Saturated/Intermittently Flooded
Baltic Rush	Alliance - A.1374	Wet Meadow	Saturated/Intermittently Flooded
Desert Salt Grass	Alliance - A.1332	Marsh/Open Water	Semipermanently Flooded, Seasonally Flooded
Desert Salt Grass	Alliance - A.1332	Wet Meadow	Intermittently Flooded/Saturated
Hardstem Bulrush	Alliance - A.1443	Marsh / Open Water	Semipermanently Flooded**,** Seasonally Flooded
Utah Swampfire	Alliance - A.1676	Wet Meadow Marsh / Open Water	Semipermanently Flooded**,** Seasonally Flooded
Spike Rush	Alliance - A.1371	Marsh / Open Water	Semipermanently Flooded**,** Seasonally Flooded
Halogeton	Alliance - B.009	Dry-Mesic Shrubland	(Upland)
Cattail	Project Code	Marsh / Open Water	Semipermanently Flooded, Seasonally Flooded
Dogbane	Project Code	Wet Meadow	Intermittently Flooded/Saturated
Milkweed	Project Code	Wet Meadow	Intermittently Flooded/Saturated
Threesquare Bulrush	Project Code	Marsh / Open Water	Semipermanently Flooded**,** Seasonally Flooded
Seepweed	Project Code	Wet Meadow	Intermittently Flooded/Saturated
Disturbed	Project Code	Disturbed	N/A
Open Water/SAV	Project Code	Marsh / Open Water	Permanently Flooded, Semipermanently Flooded, Seasonally Flooded
Playa	Project Code	Playa	Intermittently Flooded/Saturated
Infrastructure	Project Code	Infrastructure	N/A
Barren Rockface	Project Code	Barren Rockface	(Upland)

Figure-6. Habitat Map

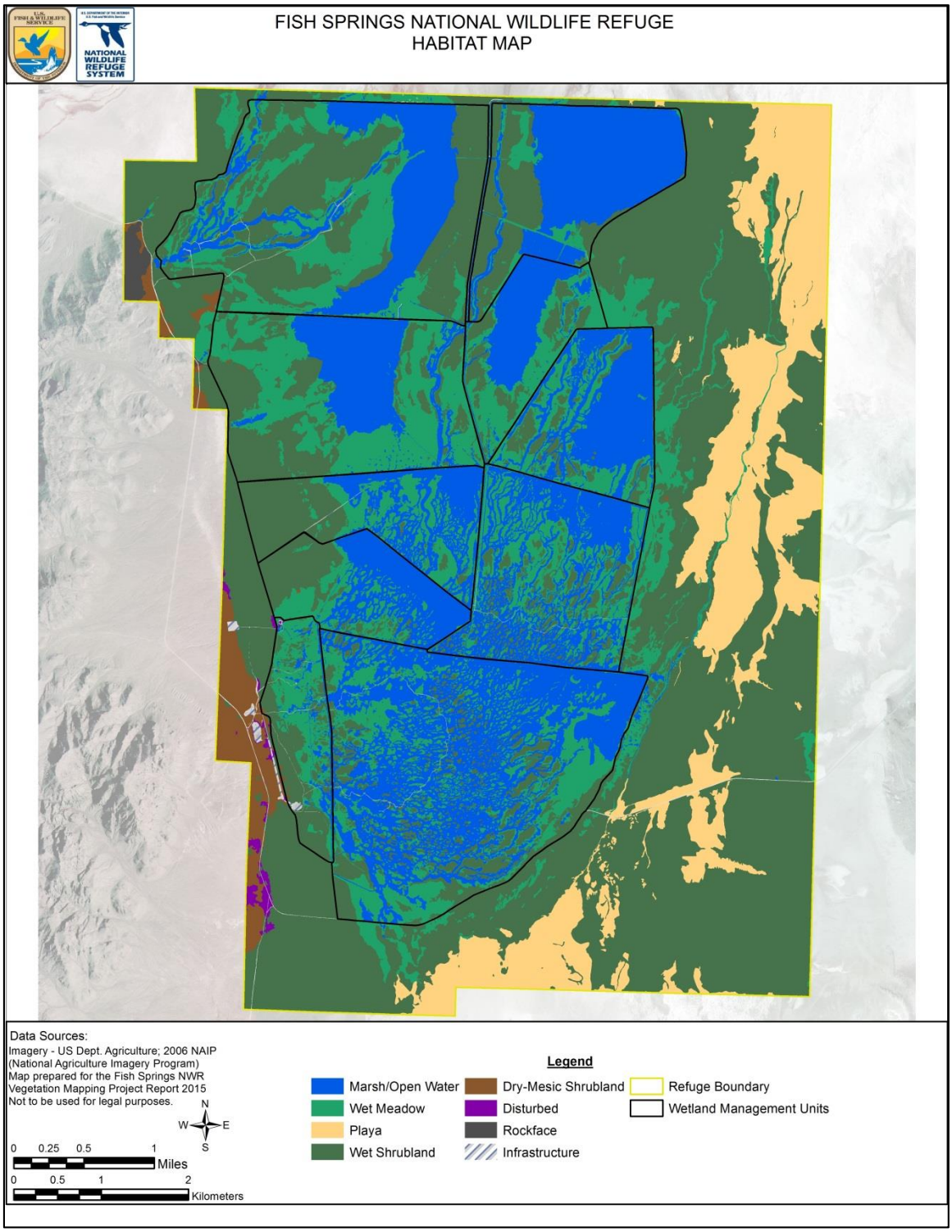


Figure-7. Water Regime Map

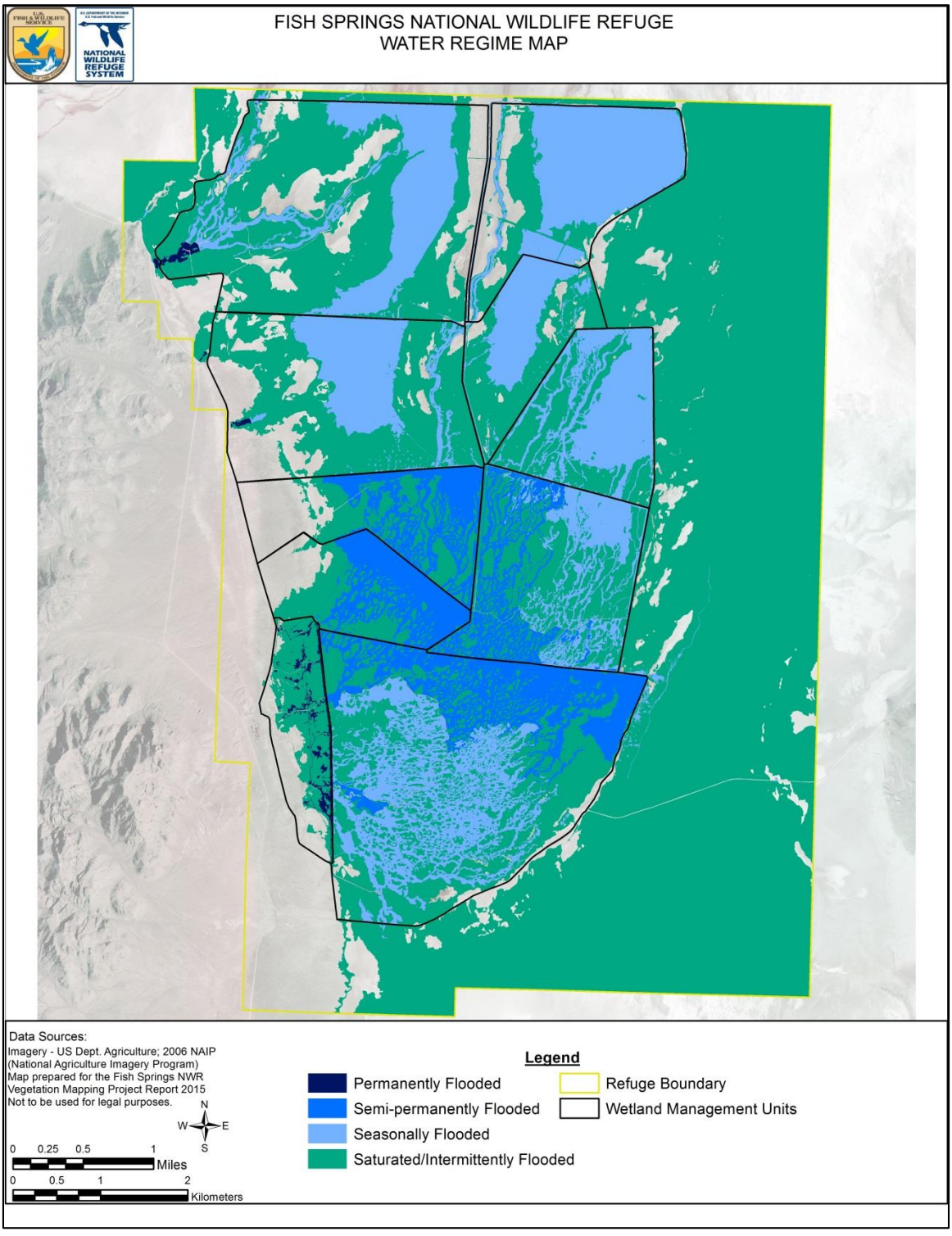


Table-4. Area calculations (in acres) for habitat and water regime mapping classification categories by management unit.

		HABITAT AND WATER REGIME BY MANAGEMENT UNITS (Acres)														
		Avocet*		Curlew*			Egret	Gadwall	Harrison	Ibis	Mallard	Non-Unit	Pintail	Shoveler	S. Springs Complex	REFUGE - WIDE
Habitat	Water Regime	Seas	Semi	Seas	Trans	Semi	Seasonal	Seasonal	Seasonal	Seasonal	Semi	Varies	Seasonal	Semi	Permanent	G. TOTAL
Marsh/Open Water**	Seasonally Flooded	649.03	--	179.69	69.85	--	371.38	563.49	495.25	207.22	--	23.14	338.64	--	--	2897.70
	Semipermanently Flooded	--	478.64	--	69.09	149.50	--	--	--	--	238.07	--	--	231.15	--	1166.44
	Permanently Flooded	--	--	--	--	--	--	--	13.04	--	--	1.87	2.62	--	34.76	52.29
Wet Meadow	Intermittently Flooded / Saturated	515.95	117.57	146.74	89.70	111.31	191.16	73.98	557.30	183.27	138.04	527.47	547.92	191.04	178.06	3569.49
Wet Shrubland**	Intermittently Flooded / Saturated	274.86	31.23	73.98	16.43	49.60	84.05	114.16	499.43	68.09	42.81	4113.65	87.37	40.75	40.42	5536.81
	(High Water Table)	61.70	--	0.29	0.03	--	1.78	150.29	319.48	32.61	93.38	1175.26	286.69	157.58	119.51	2398.61
Playa	Intermittently Flooded / Saturated	--	--	--	--	--	--	--	--	--	--	1833.07	--	--	--	1833.07
Dry-Mesic Shrubland	(Upland)	--	--	--	--	--	--	--	0.19	--	0.41	307.91	0.83	--	2.27	311.60
Disturbed	Varies	--	0.00	--	--	--	--	--	--	--	--	38.66	--	--	0.82	39.49
Infrastructure	N/A	0.01	--	--	--	--	--	--	--	--	--	14.74	--	1.22	3.00	18.98
Barren Rockface	N/A	--	--	--	--	--	--	--	--	--	--	51.14	--	--	--	51.14
															REFUGE WIDE GRAND TOTAL	17875.61

**These units contain more than one water management regime and are also sub-divided by multiple water management areas (i.e. Seasonally Flooded Area, Semipermanently Flooded Area, and Transitional Area).*

***These habitat types can be found within more than one water management regime.*

Table-5. Area calculations (in acres) for NVC mapping classification categories by management unit and water regime.

	ACRES by MANAGEMENT UNIT														REFUGE - WIDE
	Avocet*		Curlew*			Egret	Gadwall	Harrison	Ibis	Mallard	Non-Unit	Pintail	Shoveler	S. Springs Complex	
NVC Classification Category	Seas	Semi	Seas	Trans	Semi	Seasonal	Seasonal	Seasonal	Seasonal	Semi	Varies	Seasonal	Semi	Permanent	G. TOTAL
Black Greasewood	59.07	--	0.29	0.01	--	1.26	141.11	173.93	20.87	86.03	977.40	134.31	108.73	110.26	1813.28
Alkali Sacaton	79.41	6.00	34.40	4.12	9.74	19.27	3.73	29.58	52.26	13.08	136.87	159.09	11.96	8.21	567.70
Desert Salt Grass (Flooded)	302.28	33.03	111.66	43.79	15.25	244.77	141.16	65.59	75.59	0.00	0.00	77.88	53.84	1.85	1166.69
Desert Salt Grass (Non-Flooded)	319.68	58.66	53.68	43.88	30.20	106.41	23.24	102.89	41.81	74.92	169.09	115.98	121.76	62.79	1351.98
Spike Rush	0.01	0.08	0.63	0.01	0.08	0.01	0.03	--	--	0.01	0.02	0.15	0.09	0.05	1.18
Baltic Rush	83.94	12.55	40.67	22.74	13.88	30.73	13.90	181.49	78.62	27.63	93.99	62.67	31.37	17.80	711.98
Cattail	60.78	37.09	0.37	1.01	17.10	0.51	0.01	15.03	0.07	5.28	0.21	4.13	13.93	8.18	163.70
Phragmites - Dense	98.55	48.34	2.71	9.86	29.45	7.38	1.75	75.94	3.05	6.75	6.91	4.82	15.47	52.10	363.08
Phragmites - Sparse	39.14	7.57	6.24	12.39	35.85	25.88	30.99	68.57	6.01	13.57	27.52	201.54	8.84	37.79	521.90
Phragmites/Black Greasewood	--	--	--	--	0.01	--	9.18	3.00	0.39	2.88	41.34	70.48	29.01	9.25	165.53
Threesquare Bulrush	121.10	138.75	11.41	19.32	65.50	9.70	0.74	63.30	0.49	73.53	11.24	9.82	24.96	9.94	559.79
Hardstem Bulrush	1.50	22.01	0.59	1.76	0.55	7.96	0.82	2.13	2.53	3.03	1.42	6.70	3.93	0.02	54.96
Alkali Bulrush	8.70	17.20	1.23	0.24	0.03	0.97	3.68	19.75	16.48	0.01	4.23	7.97	0.75	--	81.23
Pickleweed	20.88	0.44	12.27	0.17	2.53	3.17	0.60	116.44	1.48	0.87	65.29	4.31	1.04	--	229.50
Whiteflower (Alkali) Rabbitbrush	2.63	--	--	0.02	--	0.52	--	142.55	11.35	4.47	156.51	81.90	19.84	--	419.80
Rubber Rabbitbrush	--	--	--	--	--	--	--	0.19	--	0.41	12.18	0.83	--	0.12	13.73
Mormon Tea	--	--	--	--	--	--	--	--	--	--	50.55	--	--	2.15	52.69
Allenrolfea (Iodine Bush)	274.86	31.23	73.98	16.43	49.60	84.05	444.06	499.43	68.09	42.81	4113.65	87.37	40.75	40.42	5866.71
Shadscale	--	--	--	--	--	--	--	--	--	--	16.40	--	--	--	16.40
Seepweed	0.02	--	0.04	--	--	--	--	--	--	0.01	0.01	0.06	0.44	--	0.59
Halogeton	--	--	--	--	--	--	--	--	--	--	30.75	--	--	--	30.75
Disturbed	--	0.00	--	--	--	--	--	--	--	--	7.91	--	--	0.82	8.73
Dogbane	0.30	0.09	--	--	--	--	--	--	0.47	0.08	0.00	--	--	0.04	0.98
Infrastructure	0.01	--	--	--	--	--	--	--	--	--	14.74	--	1.22	3.00	18.98
Milkweed	4.30	3.90	0.10	0.27	0.15	0.26	0.02	1.91	--	1.13	1.28	0.21	0.15	1.60	15.28
Mixed Upland Shrub	--	--	--	--	--	--	--	--	--	--	228.79	--	--	--	228.79
Open Water	24.39	210.49	50.43	69.09	40.50	105.53	86.90	322.97	111.63	156.20	7.40	233.85	133.64	14.71	1567.74
Playa	--	--	--	--	--	--	--	--	--	--	1833.07	--	--	--	1833.07
Barren Rockface	--	--	--	--	--	--	--	--	--	--	51.14	--	--	--	51.14
														REFUGE WIDE GRAND TOTAL	17877.88

**These units contain more than one water management regime and are also sub-divided by multiple water management areas (i.e. Seasonally Flooded Area, Semipermanently Flooded Area, and Transitional Area).*

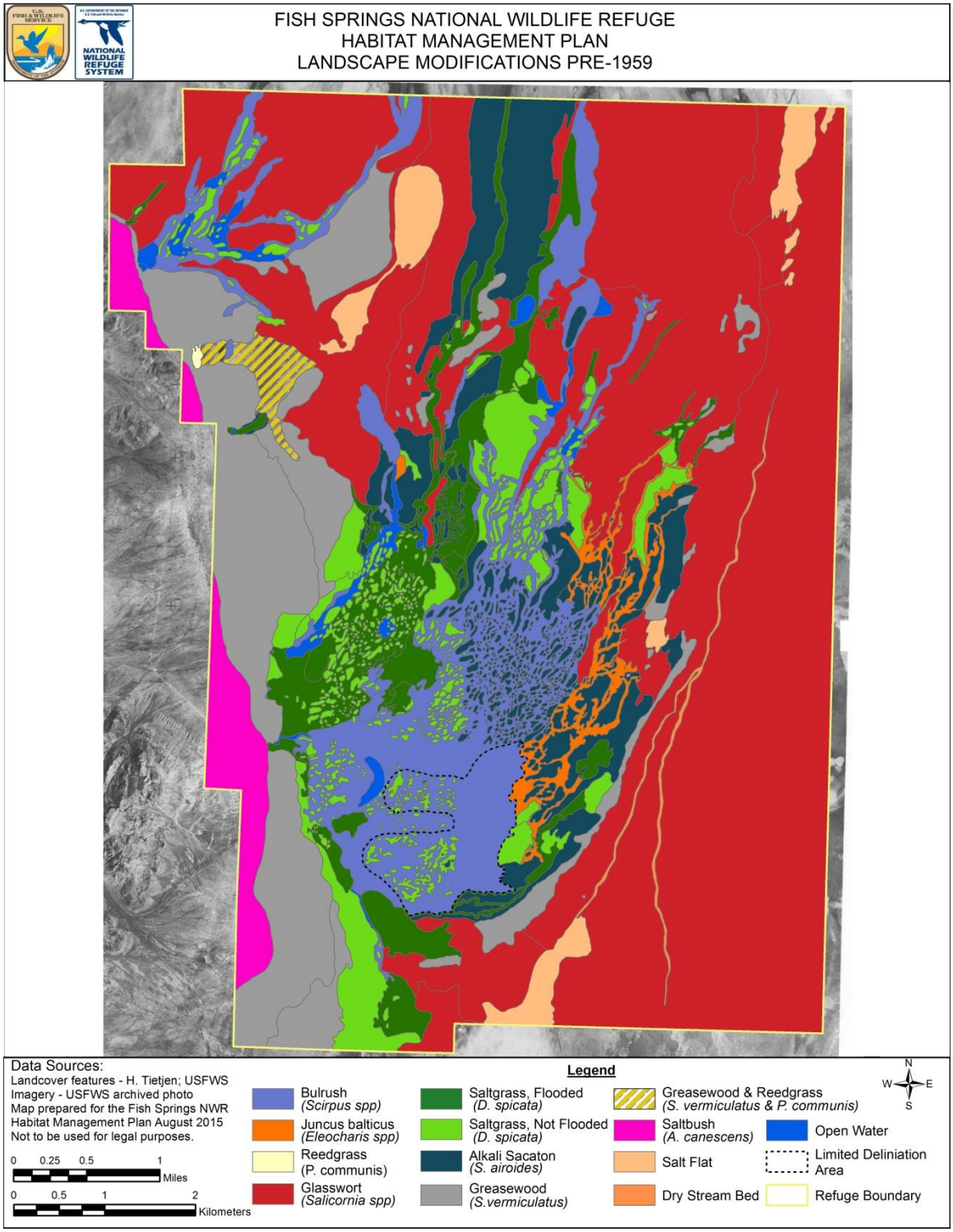
Historic Mapping Comparisons

In 1959, H. Tietjen produced a hard-copy map of the dominant vegetation occurring on the Refuge just prior to the construction of the water delivery and impoundment system. Since this map provided opportunity for a valuable historic comparison of changes in vegetation as a result of Refuge developments, JoAnn Dullum, I&M GIS manager, completed a geo-rectified and digitized copy in 2013 at the request of the refuge manager. In 2015, the digitized map was reviewed and attributed by the on-site wildlife biologist and refuge manager. Refuge staff then used the digital copy of the map for a quantitative comparison to the NVC map, as displayed in Table-6. See Figure-8 following for a printed copy of the digital map. Further discussion on comparative historic vegetation and open water changes is provided in the DHMP.

Table-6. Comparison of Historic Vegetation – Tietjen 1959 vs. current NVC.

Crosswalk for Historic Vegetation Comparison			Acres		Change (+/- acres)
NVC Alliance	HMP Classification Categories	Tietjen	HMP	Teitjen	
Schoenoplectus acutus	*Schoenoplectus acutus*	Bulrush	859.7	1989.6	-1129.9
Schoenoplectus americanus	Project Code (combined alliances) Threesquare Bulrush				
Schoenoplectus nevadensis					
Schoenoplectus pungens					
Shoenoplectus maritimus	*Shoenoplectus maritimus*				
Typha angustifolia	Project Code (combined alliances) Cattail				
Typha latifolia					
Eleocharis rostellata	*Eleocharis rostellata*		1.2	0.0	1.2
Juncus balticus	*Juncus balticus*	*Juncus balticus*	712.0	282.5	429.5
Phragmites australis	*Phragmites australis*	Reedgrass	885.0	5.8	879.2
Distichlis spicata	*Distichlis spicata*	Saltgrass	2518.7	2346.7	172.0
	**flooded*	**flooded*	*1166.7*	*1179.1*	
	**not flooded*	**not flooded*	*1352.0*	*1167.5*	
Allenrolfea occidentalis	*Allenrolfea occidentalis*	Glasswort	6516.0	8378.9	-1862.9
Sarcocornia utahensis	*Sarcocornia utahensis*				
Chrysothamnus albidus	*Chrysothamnus albidus*				
Sporobolus airoides	*Sporobolus airoides*	*Alkali sacaton*	567.7	1452.9	-885.2
Sarcobatus vermiculatus	*Sarcobatus vermiculatus*	Greesewood	1813.3	2206.2	-392.9
Sarcobatus vermiculatus	Project Code (combined alliances) Phragmites/Greesewood	Greesewood/Reedgrass	165.5	133.3	32.3
Phragmites australis					
Atriplex canescens	Project Code (combined alliances) Mixed Upland Shrub	Saltbrush	311.6	494.7	-183.1
Ephedra nevadensis					
Atriplex confertifolia					
Chrysothamnus nauseosus	*Chrysothamnus nauseosus*				
N/A	Project Code (Non-NVC) Playa	Salt Flat	1833.1	482.0	1351.1
		Dry Stream Bed			
N/A	Project Code (Non-NVC) Open Water/SAV	Open Water	1567.7	206.7	1361.0

Figure-8. Historic Dominant Vegetation Map of the Fish Springs NWR – Digitized version created by Service staff as mapped by Tietjen (1959). *Saltgrass was additionally classified in the digital map version from that completed by Tietjen as either flooded (within flooded channel braids) or not flooded (on top of island plateaus). Since the classification of individual mapping units (dominant plant stands) by Tietjen often involved lists of multiple plant species, a determination was made by Refuge staff that the species listed first was most dominant and was attributed as such in the digital map version. Also, some individual mapping units created by Tietjen were not specifically classified by a listed plant species. In these cases, Refuge staff used the same classification as the nearest or surrounding mapping units.*



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VI. APPENDICES LIST

Appendix-1: Published alliance descriptions (Peterson 2008) utilized for the NVC vegetation mapping project.

Appendix-2: Project Code (PC) descriptions for special mapping units utilized for the NVC vegetation mapping project.

Appendix-3: Breakdown of the accuracy assessment by NVC mapping unit and sampling phase.

Appendix-1. Published descriptions of Alliances (Peterson 2008).

Located following is a summary list of published alliances utilized for this mapping project. Alliances were selected from the 'International Vegetation Classification Alliance and Associates Occurring Nevada with Proposed Additions' by E. Peterson, 2008. This publication was chosen for use as Nevada contains similar ecological and geological features and Utah does not have a published alliance list available at this time. The full publication can be found at: *http://heritage.nv.gov/sites/default/files/library/ivclist.pdf*.

Mapping units of the NVC vegetation map represent dominant species of natural and semi-natural vegetation as described by published alliances, as well as and other special mapping unit classifications defined by Project Codes (see Section II above and Appendix 2). The published alliances contain descriptions that are in some instances not fully consistent with conditions for Fish Springs NWR. Where there are notable differences in conditions, these are described in italicized sections following the descriptions of each published alliance.

I.FOREST – No forest alliances were utilized for the mapping process completed at Fish Springs NWR as no forest habitat is located within Refuge Boundaries.

II.WOODLAND – No woodland alliances were utilized for the mapping process completed at Fish Springs NWR as no forest habitat is located within Refuge Boundaries.

III.SHRUBLAND

A.834. *Chrysothamnus albidus* Shrubland Alliance
White-flower Rabbitbrush Shrubland Alliance

Stands included in this shrubland alliance occur around seeps, saline meadows and flats, and around pluvial lakes in the Great Basin. The climate is arid; mean annual precipitation is generally less than 15 cm. Summers are hot and winters are cold. Elevations range from 1450-1900 m. Described stands occur on mesic sites on the nearly flat lake plain where groundwater reaches the soil surface at some time during the growing season. There are miniature pedicels with perennial grasses growing on them. Soils are generally deep, fine-textured (silty clay), poorly drained, calcareous, alkaline and saline. Stands have a sparse woody layer dominated by the microphyllous evergreen shrub *Chrysothamnus albidus*. The herbaceous layer is sparse to possibly moderately dense, but no cover values are available. The most frequent species are the graminoids *Puccinellia nuttalliana* and *Muhlenbergia richardsonis*. Other scattered species include *Distichlis spicata, Pyrrocoma uniflora var. uniflora, Nitrophila occidentalis*, and *Crepis runcinata*. Adjacent vegetation includes sparse shrublands dominated by *Sarcobatus vermiculatus* and *Atriplex confertifolia*, or *Distichlis spicata*-dominated herbaceous community.

A.835. *Ericameria nauseosa* Shrubland Alliance
Rubber Rabbitbrush Shrubland Alliance

This alliance includes both natural and semi-natural stands from localized areas across the northern Great Plains and throughout the western U.S. Naturally occurring stands have been described from areas of partially stabilized sands, in a region of actively moving dune deposits, from 1525-1800 m elevation in southeastern Idaho and in other areas of high natural disturbance such as on steep colluvial slopes, along drainages or in floodplains. The semi-natural stands included in this alliance are seral shrubland communities resulting from overgrazing by livestock, road building, or other cultural disturbance of typically grass-dominated communities. Elevations range from 1220-1800 m. Soils are variable, but generally well-drained and coarse-textured. The vegetation is characterized by a open to moderately dense, short-shrub layer (15-60% cover) that is dominated by *Ericameria nauseosa*. Depending on geography, associated shrubs may include scattered *Artemisia tridentata, Artemisia*

filifolia, Chrysothamnus viscidiflorus, Gutierrezia sarothrae, Rhus trilobata, Opuntia spp., *Prunus virginiana, Symphoricarpos occidentalis*, and *Yucca* spp. The herbaceous layer can vary from moderately dense and dominated by graminoids to absent. Common native grasses include *Achnatherum hymenoides (= Oryzopsis hymenoides), Bouteloua* spp., *Elymus trachycaulus ssp. trachycaulus, Leymus flavescens (= Elymus flavescens), Pascopyrum smithii, Pleuraphis jamesii, Pseudoroegneria spicata*, and *Sporobolus cryptandrus*. Native forbs generally have low cover. Disturbed stands typically have high cover of introduced annual *Bromus* species.

A.857. *Ephedra nevadensis* Shrubland Alliance
Nevada Joint-fir Shrubland Alliance

This arid shrubland alliance occurs in valleys, bajadas, and mountains of the Mojave Desert and Great Basin, from 600-1525 m in elevation. Sites are commonly found on all aspects in drainage bottoms, broad valleys and on alluvial fans. Topography is typically flat or undulating to moderately sloping, but can be more diverse at higher elevations. Soil textures range from sandy loams to loamy sands with rock fragments derived from alluvium. Vegetation in this shrubland alliance is characterized by a sparse to moderate cover of mixed xeromorphic short shrubs and sparse herbaceous cover. The shrub layer is usually dominated by *Ephedra nevadensis*. Characteristic codominant shrubs are *Ericameria cooperi* and *Eriogonum fasciculatum*. The shrub layer is diverse and may include *Grayia spinosa, Sarcobatus vermiculatus, Salazaria mexicana, Hymenoclea salsola, Psorothamnus arborescens*, and *Chrysothamnus* spp. Perennial grasses dominate the sparse herbaceous layer and may include *Achnatherum hymenoides (= Oryzopsis hymenoides), Elymus elymoides*, and *Poa secunda (= Poa scabrella)*. Common forbs may include perennials, such as *Mentzelia multiflora, Camissonia multijuga, Astragalus layneae*, and *Lomatium mohavense*, and annuals, such as *Eriogonum polycladon, Camissonia contorta, Navarretia* spp., *Eriastrum eremicum, Oxytheca perfoliata*, and *Phacelia* spp. Total vegetation cover is sparse on rock outcrop sites and in soils derived from granite. Diagnostic of this shrubland alliance is total vegetation cover over 25% that is dominated by *Ephedra nevadensis*.

A.866. *Allenrolfea occidentalis* Shrubland Alliance
Iodinebush Shrubland Alliance

This alliance is known from saline habitats throughout the arid western United States, as far north as Oregon, and south into Mexico. It includes vegetation dominated by *Allenrolfea occidentalis* occurring in alkaline flats along the margins of salt lakes, in depressions among gypsum ridges, and along washes in saline overflow areas. It is associated with topographic depressions usually without surface drainage (playas) and stream terraces from sea level to 1800 m (5900 feet) elevation. In all cases, it occurs at sites which are seasonally moist or flooded and where evaporation concentrates transported salts, leaving visible mineral crusts at the soil surface. The nominal species can cover large acreages, with little else except barren soil. Associated species in western Texas occurrences include *Suaeda suffrutescens var. detonsa, Sporobolus airoides, Sporobolus wrightii, Tamarix ramosissima, Atriplex canescens*, and *Distichlis spicata*. In Utah, *Allenrolfea occidentalis* may occur with *Atriplex gardneri* or scattered *Sarcobatus vermiculatus*.

A.869. *Atriplex canescens* Shrubland Alliance
Fourwing Saltbush Shrubland Alliance

This alliance occurs primarily in arid and semi-arid areas of the southwestern U.S. from western Texas to southern and eastern California and into Chihuahua, Mexico. It is also found in the western Great Plains to the Great Basin from western Kansas, Colorado, and Wyoming to Utah, Nevada and eastern Oregon. Associations in this alliance vary throughout the range and occur in a variety of environmental settings. In western Texas, this alliance occupies alkaline flats, depressions among gypsum ridges, saline or sandy soils. Overall, shrublands in this alliance occur on lowland and upland sites with elevation ranging from 75 m below sea level to 2400 m. Lowland sites include alluvial flats, drainage terraces, playas, washes and interdune basins. Upland sites include bluffs and gentle to

moderately steep, sandy or rocky slopes. Stands occur on all aspects. Soils are variable with depths ranging from shallow to moderately deep, and texture ranging from sand to loam to clay. The lowland sites may be moderately saline or alkaline.

Stands typically have a sparse to moderately dense (10-60% cover) short-shrub canopy (approximately 1.5 m tall) that is dominated by the facultative deciduous, xeromorphic shrub *Atriplex canescens*, with bare ground usually dominating the ground surface. Associated shrubs may include *Artemisia bigelovii, Artemisia tridentata, Ephedra viridis, Krascheninnikovia lanata, Purshia stansburiana (= Purshia mexicana var. stansburiana), Psorothamnus polydenius, Parthenium confertum, Sarcobatus vermiculatus*, and species of *Chrysothamnus, Ericameria*, and *Lycium*. Dwarf-shrubs, such as *Gutierrezia sarothrae* or *Eriogonum* spp., may be common in some stands. The sparse to moderately dense graminoid layer (1-60% cover) is typically dominated by warm-season, medium-tall and short grasses. The species present depend on geographic range of the grasses and past land use. Species may include *Bouteloua gracilis, Distichlis spicata, Elymus elymoides, Hesperostipa comata, Pleuraphis jamesii (= Hilaria jamesii), Achnatherum hymenoides (= Oryzopsis hymenoides), Muhlenbergia porteri, Scleropogon brevifolius, Pascopyrum smithii*, and *Sporobolus* spp. Forb cover is generally sparse, but annual forbs such as *Calycoseris parryi* may be abundant in wet years. Common forbs include species of *Sphaeralcea, Dalea, Cymopterus, Chenopodium, Kochia, Iva, Picradeniopsis*, and *Ratibida*. Cacti from the genus *Opuntia* are associated species in some stands. Trees are typically not present, but occasionally scattered *Juniperus* spp. occur. Very little is known about the expression of this alliance in the Midwest.

A.870. *Atriplex confertifolia* Shrubland Alliance
Shadscale Shrubland Alliance

This shrubland alliance occurs across the western U.S. from the eastern Mojave Desert and Great Basin east to the western Great Plains. These shrublands are usually associated with valley bottoms or alluvial slopes with medium- to fine-textured soils but may occur on coarser soils of erosional slopes with calcareous substrates. In most cases, the soils are alkaline and may have substantial salt accumulation. The vegetation included in this alliance is characterized by a sparse to moderately dense shrub layer dominated or codominated by *Atriplex confertifolia*. Shrub associates may include *Picrothamnus desertorum (= Artemisia spinescens), Atriplex polycarpa, Ephedra nevadensis, Chrysothamnus* spp., *Krascheninnikovia lanata, Lycium* spp., *Sarcobatus vermiculatus*, and *Tetradymia* spp. The usually sparse herbaceous layer is dominated by graminoids such as *Elymus elymoides, Pleuraphis jamesii (= Hilaria jamesii), Pleuraphis rigida (= Hilaria rigida), Leymus salinus, Achnatherum hymenoides (= Oryzopsis hymenoides), Pseudoroegneria spicata, Hesperostipa* spp., and other perennial bunch grasses. Diagnostic of this shrubland alliance is a shrub layer dominated or codominated by *Atriplex confertifolia*.

A.1041. Sarcobatus vermiculatus Shrubland Alliance
Black Greasewood Shrubland Alliance

This widespread shrubland alliance has been described from badlands in the northern Great Plains, silt dunes around pluvial lakes in the Great Basin, and alluvial plains in north-central New Mexico. Sites are nearly flat to steep and are located on contouring microbenches on middle or lower slopes with generally southern aspects. The microbenches are the result of differential erosion of shale layers. Lowland sites may receive overland flow during intense summer thunderstorms, but drain and are not considered flooded. However, some sites have high water tables. Soils are generally fine textured, poorly drained, calcareous, alkaline and saline. Soils from some sites have large amounts of rock. The soil surface is mostly bare ground often with white salt crust. Shrublands included in this alliance are dominated by *Sarcobatus vermiculatus*. Other characteristic shrubs and dwarf-shrubs may include *Artemisia tridentata, Atriplex canescens, Atriplex confertifolia, Chrysothamnus* spp., *Grayia spinosa, Gutierrezia sarothrae*, or *Suaeda moquinii*. The herbaceous layer is absent to moderately sparse (<25%) and composed of scattered perennial grasses, such as *Pseudoroegneria spicata, Pleuraphis jamesii (= Hilaria jamesii), Achnatherum hymenoides (= Oryzopsis hymenoides), Sporobolus*

cryptandrus, and *Bouteloua gracilis*. Annual grasses, especially the exotics *Bromus tectorum* and *Bromus japonicus*, may be present. Forbs are sparse except on disturbed, weedy sites. Forb species may include *Eriogonum pauciflorum, Suaeda calceoliformis, Thelypodium sagittatum, Halogeton glomeratus*, and *Lepidium perfoliatum*. Occasionally cacti, small trees or yucca may be present in New Mexican stands. Diagnostic of this alliance is the *Sarcobatus vermiculatus*-dominated shrub layer in a shrubland that has a relatively shallow water table, but is not flooded.

V.HERBACEOUS VEGETATION

A.941. *Suaeda moquinii* Intermittently Flooded Shrubland

Shrubby Seepweed Intermittently Flooded Shrubland Alliance

Shrublands in this alliance occur in desert basins or playas in Nevada, Arizona, and southern and eastern California. Elevations range from sea level to 1600 m. Climate is arid to semi-arid with hot summers. Winter rain makes up the majority of the annual precipitation. Sites are generally flat to gently sloping saline valley bottoms and playas. Soils are deep, saline, alkaline, clay loams. The vegetation has a generally sparse shrub layer that is less than 1.5 m tall and is strongly dominated by *Suaeda moquinii* with scattered *Atriplex polycarpa, Atriplex canescens, Allenrolfea occidentalis*, or *Sarcobatus vermiculatus* in some stands. The sparse herbaceous layer includes the forbs *Bassia hyssopifolia* and *Salicornia maritima (= Salicornia europaea)*. Graminoids are typically not present except for occasional *Sporobolus airoides*. The adjacent shrublands are dominated by *Sarcobatus vermiculatus* or *Atriplex polycarpa*.

A.1331. *Sporobolus airoides* Intermittently Flooded Herbaceous Alliance

Alkali Sacaton Intermittently Flooded Herbaceous Alliance

This alliance includes vegetation characterized by *Sporobolus airoides*, typically in saline or alkaline habitats. In western Texas, communities of this alliance are found in depressions among gypsum ridges and on salt flats at elevations around 1100 m (3600 feet). Associates known from western Texas occurrences include *Allenrolfea occidentalis, Suaeda suffrutescens, Atriplex canescens, Tamarix ramosissima, Isocoma pluriflora, Hoffmannseggia glauca, Cressa truxillensis, Frankenia jamesii, Tiquilia hispidissima, Dicranocarpus parviflorus, Brickellia eupatorioides var. chlorolepis, Lepidium montanum*, and *Sphaeralcea hastulata*. The main distribution of this alliance is west of Texas, with associations in Arizona, New Mexico, Colorado, Kansas, Montana, and possibly in California.

A.1332. *Distichlis spicata* Intermittently Flooded Herbaceous Alliance

Saltgrass Intermittently Flooded Herbaceous Alliance

This alliance occurs throughout much of the semi-arid and arid western U.S. on saline or alkaline soils in lowland sites such as playas, swales and terraces along washes that are intermittently flooded. The flooding is usually the result of highly localized thunderstorms. The unpredictable nature of the flooding is the key environmental factor separating this alliance from similar alliances with more predictable flooding regimes. Soils are deep, saline, alkaline and fine-textured. They generally have an impermeable layer and therefore are poorly drained. When the soil is dry, the surface usually has salt accumulations. This intermittently flooded grassland of playas and ephemeral streams has a sparse to dense herbaceous layer that is dominated by *Distichlis spicata*, sometimes occurring in nearly pure stands. The level of salinity in the soil may restrict associated species. Associated graminoids may include *Puccinellia nuttalliana, Hordeum jubatum, Pascopyrum smithii, Sporobolus airoides, Carex filifolia*, and *Juncus balticus*. Forb cover is generally low and may include *Salicornia rubra, Triglochin maritima, Suaeda calceoliformis (= Suaeda depressa), Helianthus* spp., and Asteraceae spp. Diagnostic of this alliance is the *Distichlis spicata*-dominated herbaceous layer and the presence of surface water for brief periods at unpredictable times during the growing season.

Note: The description of this published alliance (Peterson 2008) is not fully accurate of conditions at Fish Springs NWR. There is widespread occurrence of Distichlis spicata as a dominant species within

seasonally flooded, intermittently flooded, saturated water regimes. The species also exists to some degree as a dominant species within semi-permanently flooded sites. See Bolen 1964 for a site-specific description of Distichlis spicata.

A.1371. Eleocharis (montevidensis, palustris, quinqueflora)* Seasonally Flooded Herbaceous Alliance

Sand Spikerush, Marsh Spikerush, Few-flower Spikerush Seasonally Flooded Herbaceous Alliance

**E. rostellata Torr. is the spikerush species recorded on the Refuge (CCP, 2004). All other descriptors for this Alliance remain the same.*

Stands of this widespread western grassland alliance require seasonally to permanently saturated soils. Stands cannot tolerate permanent standing water, but often grow on the saturated soils surrounding a permanent water body, or on depressions subject to seasonal flooding. Stands are found from sea level to 2500 m elevation in meadows, seeps, swales, and shorelines. Water chemistry is fresh. Precipitation averages from 50-250 cm per year, and falls mostly from November to May. Stands of this western wetland herbaceous alliance are dominated by one or more species of *Eleocharis*. Species may include *Eleocharis quinqueflora (= Eleocharis pauciflora), Eleocharis palustris, Eleocharis montevidensis*, and/or *Eleocharis rostellata*. Other species present may include *Muhlenbergia asperifolia, Oreostemma alpigenum (= Aster alpigenus), Carex utriculata, Carex* spp., *Schoenoplectus americanus (= Scirpus americanus), Scirpus* spp., *Oxypolis occidentalis, Triglochin palustris, Phleum alpinum, Juncus nevadensis, Mimulus primuloides, Crassula aquatica*, and *Callitriche hermaphroditica*.

A.1374. *Juncus balticus* Seasonally Flooded Herbaceous Alliance

Baltic Rush Seasonally Flooded Herbaceous Alliance

This alliance often occupies seasonally flooded swales and wet, low- to mid-elevation sites. Habitats are often alkaline meadows and may have long-term grazing disturbance. It is a wide-ranging alliance, occurring from the plains to montane regions to boreal regions, and has much variability. Elevations range from sea level in California to 3500 m in Colorado. Montane plant associations can occur on alluvial terraces, floodplains, overflow channels, seeps, meadows, and near springs. Sites are typically gently sloping (1-3%) on all aspects. An association was documented in northern California coastal salt marshes. Soils are mineral with dark surface horizons containing large amounts of welldecomposed organic matter. Soils are Mollisols or rarely Entisols. Soil texture ranges from silt to sandy loam. Water tables are often at or near the soil surface in early summer but may drop below 50 cm by late August. Soil reaction ranges from neutral to mildly alkaline (pH 7.0-8.0).

The graminoid layer is dense with up to 98% cover and dominated by *Juncus balticus*, a creeping, often sod-forming, rhizomatous perennial. Other graminoid cover is minor but can include *Carex pellita (= Carex lanuginosa), Carex aquatilis, Carex canescens, Leymus cinereus, Deschampsia caespitosa,Hordeum jubatum*, or *Sporobolus airoides*. Forb cover is typically minor and may include *Achillea millefolium, Iris missouriensis*, or *Geum macrophyllum*. The plant associations from California are composed of various forbs and the graminoids *Bromus* spp., *Distichlis spicata, Carex lyngbyei, Carex obnupta, Hordeum brachyantherum, Leymus triticoides, Lolium perenne ssp. multiflorum*, and *Schoenoplectus robustus (= Scirpus robustus)*. Occasionally, a few tree or shrub seedlings are present, including *Populus angustifolia, Dasiphora fruticosa ssp. floribunda (= Pentaphylloides floribunda)* , and *Salix exigua*. *Salix exigua* shrublands, *Distichlis spicata* marshes, or *Carex* spp. meadows may occur in adjacent riparian areas. *Abies lasiocarpa - Picea engelmannii, Pseudotsuga menziesii*, and *Populus tremuloides* forests, *Pinus edulis - Juniperus* spp. woodlands, and *Ericameria nauseosa (= Chrysothamnus nauseosus), Sarcobatus vermiculatus*, and *Artemisia tridentata* shrublands may occur on adjacent hillslopes.

In low-disturbance areas, *Juncus balticus* plant associations appear to be a stable, climax community. However, in some areas, this association is considered to be grazing-induced. *Juncus balticus* is considered an increaser due to its low forage value and high tolerance to grazing. It usually increases

in abundance on sites formerly dominated by *Deschampsia caespitosa* or *Calamagrostis canadensis*. Nearly pure stands of *Juncus balticus* indicate that the site may have been heavily grazed in the past. *Juncus balticus* is listed as a facultative wetland species.

Note: The description of this published alliance (Peterson 2008) is not fully accurate of conditions at Fish Springs NWR. Occurrence of Juncus balticus as a dominant species is most typical of intermittently flooded and saturated water regimes. See Bolen 1964 for a site-specific description of Juncus balticus.

A.1392. *Typha domingensis* Seasonally Flooded Temperate Herbaceous Alliance
Southern Cattail Seasonally Flooded Temperate Herbaceous Alliance

This alliance includes temperate, non-tidal wetlands dominated by *Typha domingensis*. This includes wet parts of non-tidal interdune ponds with brackish water from hurricane flooding, storm tides, or island overwash. Other characteristic species may include *Setaria magna* and *Cyperus* spp. This alliance can be zonal with other vegetation including *Leptochloa fusca ssp. fascicularis (= Leptochloa fascicularis var. maritima)* and alien *Phragmites australis*. This alliance occurs in coastal areas of North Carolina, South Carolina, Florida, Texas, and in scattered localities in the mountains of Colorado and Utah, and the intermountain desert region of California, Arizona and Nevada.

Note: The description of this published alliance (Peterson 2008) is not fully accurate of conditions at Fish Springs NWR. There is widespread occurrence of Typha domingensis as a dominant species within permanently flooded, semi-permanently flooded, and seasonally flooded water regimes.

A.1407. *Spartina gracilis* Seasonally Flooded Herbaceous Alliance
Alkali Cordgrass Seasonally Flooded Herbaceous Alliance

This tall grassland alliance is found on scattered low-elevation sites of the northern and western Great Plains, and in northern portions of the Intermountain West. Locations supporting this alliance are moist, poorly drained, often alkaline areas along ephemeral, intermittent or perennial streams, as well as swales, meadows, the margins of marshes and ponds and on moist sandy overflow channels and backwater areas of large rivers. Water tables are typically high, within 1 m of the surface, but the sites are not permanently flooded. Soils are fine-textured, and range from clays to silt-loam, and are usually slightly to moderately alkaline, but non-saline. Vegetation included in this alliance is characterized by a tall perennial graminoid layer that is dominated by *Spartina gracilis*, sometimes forming pure stands. Other graminoids present, and occasionally codominant, include *Schoenoplectus pungens (= Scirpus pungens), Juncus balticus*, and *Pascopyrum smithii*. Forb species tend to be weedy, such as *Grindelia squarrosa, Glycyrrhiza lepidota*, and *Xanthium strumarium*. These forbs can be somewhat abundant in disturbed locations, but otherwise are found in small amounts. Diagnostic of this alliance is the *Spartina gracilis*-dominated tall graminoid layer in a grassland that has a relatively shallow water table and is flooded for an extended period during the growing season.

A.1431. *Phragmites australis* Semipermanently Flooded Herbaceous Alliance
Common Reed Semipermanently Flooded Herbaceous Alliance

This alliance consists of non-tidal *Phragmites* marshes with semipermanently or, rarely, seasonally flooded hydrology, occurring either in depressions or along rivers with seasonal fluctuation in water level throughout the United States and adjacent Canada. This includes semipermanently flooded marshes, ditches, impoundments, etc., which are strongly dominated by essentially monospecific stands of *Phragmites australis*, which is rapidly spreading in disturbed areas and excluding native vegetation. Stands may be composed entirely of *Phragmites australis*, with few or no other vascular plants present.

Note: The description of this published alliance (Peterson 2008) is not fully accurate of conditions at Fish Springs NWR. See Bolen 1964 for a site-specific description of Phragmites australis, which exists in two distinct forms, dense and sparse, and is most often present within intermittently flooded and saturated water regimes. The use of this alliance represents areas with a dominant canopy cover of the dense form. Two other special mapping units containing P. australis are used (see Appendix 2).

A.1432. *Schoenoplectus americanus* Semipermanently Flooded Herbaceous Alliance
Chairmaker's Bulrush Semipermanently Flooded Herbaceous Alliance

This alliance, found in the southern Great Plains and several western states, contains bulrush wetlands dominated by *Schoenoplectus americanus (= Scirpus americanus)*. This alliance is not well understood across its range. In cienegas in Trans-Pecos Texas (and possibly also in southern New Mexico), *Schoenoplectus americanus* typically dominates the stands, though *Flaveria chlorifolia* or *Helianthus paradoxus* may be locally dominant. Other species include *Samolus ebracteatus ssp. cuneatus, Limonium limbatum*, and *Distichlis spicata*. Most examples of this community have been hydrologically altered by use of water for irrigation. Elsewhere in Texas it occurs in permanent springs where species may include *Schoenoplectus americanus, Eleocharis macrostachya, Fuirena simplex, Paspalum distichum, Potamogeton illinoensis*, and in outer zones, *Andropogon gerardii*. *Schoenoplectus americanus*-dominated marshes occur throughout Oklahoma, but are most common in the central and western portions of the state, and in the panhandle. Further study is needed to characterize this alliance.

A.1433. *Schoenoplectus pungens* Semipermanently Flooded Herbaceous Alliance
Common Threesquare Semipermanently Flooded Herbaceous Alliance

This alliance, found in the northern Great Plains, Utah, Nevada, and southern British Columbia and Alberta, Canada, is made up of graminoid-dominated communities found in saline or alkaline wetlands. This alliance occurs in depressions and stream or river valleys. The loam to sandy loam soils are deep, poorly drained and formed in alluvium (Steinauer 1989). These soils are slightly to strongly affected by soluble salt. Standing water is at or near the surface for most of the year. Medium tall and short graminoids predominate. Woody species are very uncommon. *Schoenoplectus pungens (= Scirpus pungens), Suaeda calceoliformis, Distichlis spicata* (on drier margins), and *Ruppia maritima* are all common species. *Chenopodium incanum, Monolepis nuttalliana*, and *Picradeniopsis oppositifolia* are sometimes abundant on less saline portions of the alliance.

A.1443. *Schoenoplectus acutus - (Schoenoplectus tabernaemontani)* Semipermanently Flooded
Hardstem Bulrush - (Softstem Bulrush) Semipermanently Flooded Herbaceous Alliance

This alliance is found in the midwestern and western United States and central Canada. Stands of this alliance are flooded for most or all of the growing season and can have water from 0 (exposed soil) to approximately 1.5 m deep, but usually is less than 1 m. Within a stand, water levels can vary by up to 1 m during the year. The water can be fresh to mildly saline throughout most of this alliance's range; however, in the Nebraska Sandhills, some stands occur in moderately alkaline water. Across the range of this alliance, soils are deep, poorly drained, muck, peat, or mineral. Vegetation is characterized by medium to tall graminoids which typically range from 1 to over 2 m. The vegetation is moderately dense to dense. Some stands are heavily dominated by one or two *Schoenoplectus* spp. (= *Scirpus* spp.), while others have several graminoids common throughout the stand. The most abundant species are typically *Schoenoplectus acutus (= Scirpus acutus), Schoenoplectus fluviatilis (= Scirpus fluviatilis)*, and *Schoenoplectus tabernaemontani (= Scirpus tabernaemontani)*. Species composition and abundance can vary from year to year depending mostly on water level fluctuations. In most years, typical species include *Lemna* spp., *Phragmites australis, Schoenoplectus americanus (= Scirpus americanus)* (in alkaline stands), *Triglochin maritima* (in alkaline stands), *Typha latifolia*, and *Utricularia macrorhiza*. *Potamogeton* spp. often occur in the deeper parts of stands of this alliance and where emergent species are not densely packed. Shrubs, such as *Salix* spp., are not common but may

become established in shallow water areas. During droughts, species more tolerant of low water, such as *Polygonum amphibium*, may invade and alter the species composition of stands of this alliance.

A.1444. *Schoenoplectus maritimus* Semipermanently Flooded Herbaceous Alliance
Saltmarsh Clubrush Semipermanently Flooded Herbaceous Alliance

Stands of this saline emergent wetland alliance are scattered from California to New York, mostly in the northern half of the United States and the southern Prairie Provinces of Canada. This description is based on the two communities that occur in the Midwest. The dominant vegetation is medium-tall graminoids with a sparse to complete canopy. Woody species are very rare, and forbs are common in some eastern stands but rare in most of the Great Plains. Stand-to-stand species variability can be substantial, especially east of the Great Plains, where the stands tend to be smaller and more isolated. The most abundant species across the range of this alliance is *Schoenoplectus maritimus (= Scirpus maritimus)*, often with smaller amounts of *Schoenoplectus americanus (= Scirpus americanus), Sium suave*, and *Typha* spp. Species common in the Great Plains include *Juncus balticus, Schoenoplectus acutus (= Scirpus acutus), Scolochloa festucacea*, and *Triglochin maritima*. *Symphyotrichum lanceolatum (= Aster lanceolatus), Atriplex patula, Eleocharis parvula*, and *Hibiscus moscheutos* are found from Illinois eastward.

Stands of this alliance are flooded by shallow saline water for much of the growing season and saturated for nearly all of it. In the Great Plains these sites are typically near shallow marshes, ponds, or lakes, while in Michigan they may also occur near rivers and streams. The soils are fine-textured and vary from fine sandy loams to mucks.

A.1676. *Sarcocornia utahensis - Arthrocnemum subterminale* Semipermanently Flooded Herbaceous
Utah Swampfire - Parish's Glasswort Herbaceous Alliance - No summary available.

A. 1814. *Bromus tectorum* Semi-natural Herbaceous Alliance
Cheatgrass Semi-natural Herbaceous Alliance

This alliance is found throughout much of western North America from the western Great Plains to intermountain and southwestern U.S. Elevation ranges from sea level to 2200 m. It occurs after disturbance of a natural shrub- or grass-dominated community resulting in the replacement of the natural vegetation by non-native, annual grass species of *Bromus*. *Bromus tectorum* typically dominates the community with over 80-90% of the total vegetation cover, making it difficult to determine what natural community was formerly present. This alliance also includes grasslands dominated or codominated by other Eurasian introduced annual *Bromus* species such as *Bromus hordeaceus, Bromus madritensis, Bromus japonicus, Bromus rigidus*, or *Bromus rubens*, but is distinct from the annual *Bromus* communities found along the Pacific Coast with Mediterranean or maritime climates.

B.009. *Halogeton glomeratus* Semi-natural Herbaceous Vegetation Alliance*
Halogeton Semi-natural Herbaceous Vegetation Alliance

**B.009 is a new 'proposed' alliance listed within Peterson, 2008. We utilized this proposed alliance as we had habitat meeting the descriptive criteria.*

This alliance describes areas so invaded by *Halogeton glomeratus* that a native vegetation type cannot be applied. Other invasive species are often present,including *Lepidium perfoliatum, Bromus tectorum*, and *Sisymbrium altisimum*. Although, *H. glomeratus* is a very widespread invasive, it typically does not significantly displace native species. However, a site in Utah has been documented where it displaced *Krascheninnikovia lanata* after flooding. A number of sites have been observed where it dominates in Nevada, usually with dozens of hoof prints per square meter suggesting that intensive grazing may be relevant to its dominance.

Appendix-2. Project Code (PC) descriptions for special mapping units.

A Project Code (PC) was utilized as a special mapping unit within the NVC mapping project to meet the following circumstances:

4) A published alliance (Peterson 2008) was not available or did not adequately match the dominate vegetation present;

5) Alliances were combined into one type of mapping unit when distinguishing between similar species was not deemed important to management needs, and accurate identification of involved species would prove too difficult or time consuming for efficient staff use;

6) Areas within the Refuge lacked the presence of a natural or semi-natural plant species meeting NVC diagnostic criteria for dominant vegetation. These non-NVC mapping units allow for full landscape coverage of the Refuge.

PCs for dominant species with no published alliances available

Dogbane

This PC represents areas with dominant vegetation cover of dogbane (*Apocynum cannabinuum* formerly *A. sibiricum* Jacq.*). Patches occur primarily within the southern end of the Refuge along the edges of standing water.

Milkweed

This PC represents areas comprised of dominant vegetation cover of two milkweed species: showy milkweed (*Asclepias speciosa* Torr.) and swamp milkweed (*A. incarnate* L.). These species occur primarily within the southern region and the northwest corner of the Refuge, near the edges of standing water.

Seepweed

This PC represents areas containing dominant vegetation cover of two species of sweepweed (one or both): Pursh Seepweed (*S. calceoliformis* (Hook.) Moq. -formerly *S. occidentalis* S. Wats.*) and Mojave seablite (*Suaeda moquinii* (Torr.) Greene - formerly *S. intermedia* S. Wats.*). Although seepweed is found within intermittently flooded and saturated wetland habitats across the Refuge, it rarely met diagnostic criteria as a dominant species.

PCs for combined alliances

Saltbrush (A.869, A.870)

This PC represents areas comprised of fourwing saltbrush (*Atriplex canescens)* and shadscale (*A. confertifolia)*, as these two species are often found intermixed as a co-dominant within dry-mesic shrubland habitat.

Mixed Upland Shrub (A.834, A.857, A.869, A.870, A.1041)

This PC represents areas that occurred within dry-mesic shrubland habitat where two or more shrub species provide co-dominant canopy coverage, including: fourwing saltbrush (*Atriplex canescens),* shadscale (*A. confertifolia)*, Mormon tea (*Ephedra nevadensis*), black greasewood (*Sarcobatus* vermiculatus) and rubber rabbitbrush (*Ericameria nauseosa*).

Threesquare Bulrush (A.1432, A.1433)

This PC represents areas comprised of dominant vegetation cover of three similar bulrush species: Olney's bulrush (*Schoenoplectus americanus* - formerly *Scirpus americanus* Pers.*), common threesquare (*Schoenoplectus pungens* - formerly *Scirpus punges* Vahl.*), and Nevada bulrush (*Scirpus nevadensis* S. Wats). Two of the three species have a published alliance description within Peterson 2008.

Cattail (featuring A.1392)

This PC was used to represent areas with dominant vegetation cover of two cattail species: broadleaf cattail (*Typha dominensis* Pers.) and narrowleaf cattail (*T. latifolia* L.), although *T. dominensis* is the most commonly occurring species. The descriptors in A.1392 are most typical for this PC.

Phragmites – Sparse (special designation from A.1431)

This PC represents areas with *P. australis* as the uppermost strata of vegetation where stands are interspersed with other vegetative species that in some instances have a higher percentage of total canopy cover. This PC was primarily created and utilized to support management needs.

The mapping unit "Phragmites – Dense" alternatively represents *P. australis* as the uppermost strata of vegetation where existing as dense mono-dominant stands, and more accurately represents use of the published alliance A.1431. See Bolen 1964 for a description of sparse and dense forms of *P. australis.*

Phrag/Black Greasewood (A.1431, A.1041)

This PC represents areas with dominant canopy coverage of ≥10% black greasewood (*Sarcobatus vermiculatus),* with the presence of the sparse form of *P. australis*. This special PC featuring two alliances allows accurate measure of area for both species for management purposes. Habitat conditions are closer aligned to those outlined in A.1041 (Black Greesewood Shrubland Alliance). See Bolen 1964 for a description of sparse and dense forms of *P. australis.*

<u>PCs for non-NVC mapping units</u>

Disturbed

This PC was represents areas that have been previously disturbed by humans, and exist as either disturbed soil without vegetative cover or contained non-native plant species. These areas are primarily located along roadsides and housing/office areas. The most predominately occurring species included within this PC was forage kochia (*Bassia prostrate*).

Open Water/SAV

This PC represents areas of open water that most often contain submerged aquatic vegetation (SAV). The most commonly occurring species of SAV on the Refuge include: sago pondweed (*Stuckenia pecinata*), widgeon grass (*Ruppia maritimus*), spiny naid (*Najas marina*), and coon's tail (*Ceratophyllum demersum*), as well as a plant-like algae, Muskgrass (*Chara spp.*).

Infrastructure

This PC represents areas where buildings or other man-made structures are located. These are areas where there is no natural vegetation cover meeting project diagnostic criteria.

Playa

This PC represents areas that have no vegetation cover meeting project diagnostic criteria and are comprised of alkali mudflat.

Barren Rockface

This PC represents areas comprised of rock outcroppings or rock face along the Fish Springs Range that lack vegetative cover meeting project diagnostic criteria.

Appendix-3. Breakdown of the accuracy assessment by NVC mapping unit and sampling phase.

Mapping Unit	Type	# Sites North	# Sites South	Total # Sites	# Sites Wrong	% Accuracy	Wrong Label	Near - but not at Point	Edge Wrong
Allenrolfea occidentalis Shrubland Alliance	A.866	20	21	41	0	100.0%	0	0	0
Sarcobatus vermiculatus Shrubland Alliance	A.1041	20	19	39	1	97.4%	1	0	0
Ephedra nevadensis Shrubland Alliance	A.857	0	20	20	0	100.0%	0	0	0
Schoenoplectus maritimus Semipermanently Flooded Herbaceous Alliance	A.1444	20	21	41	1	79.6%	0	0	1
Spartina gracilis Seasonally Flooded Herbaceous Alliance	A.1407	0	0	0	0	N/A	0	0	0
Sporobolus airoides Intermittently Flooded Herbaceous Alliance	A.1331	20	21	41	0	100.0%	0	0	0
Juncus balticus Seasonally Flooded Herbaceous Alliance	A.1374	21	19	40	1	97.5%	1	0	0
Bromus tectorum Semi-natural Herbaceous Alliance	A.1814	0	0	0	0	N/A	0	0	0
Distichlis spicata Intermittently Flooded Herbaceous Alliance	A.1332	20	21	41	1	97.6%	1	0	0
Schoenoplectus acutus - (*Schoenoplectus tabernaemontani*) Semipermanently Flooded	A.1443	21	19	40	3	92.5%	1 / 2	0	0
(*Sarcocornia utahensis*) - (*Arthrocnemum subterminale*) Semipermanently Flooded Herbaceous	A.1676	20	19	39	1	97.4%	1	0	0
Eleocharis (*montevidensis, palustris, quinqueflora*) Seasonally Flooded Herbaceous Alliance	A.1371	11	20	31	1	96.8%	1	0	0
Phragmites australis Semipermanently Flooded Herbaceous Alliance	A.1431	20	20	40	1	97.5%	1	0	0
Phragmites australis - Sarcobatus vermiculatus Mixed	PC	19	20	39	0	100.0%	0	0	0
Phragmites australis - Sparse	PC	21	20	41	0	100.0%	0	0	0
Rabbitbrush Shrubland*	PC	20	19	39	2	94.9%	2	0	0
Saltbrush Shrubland	PC	0	3	3	0	100.0%	0	0	0
Mixed Upland Shrubland	PC	8	12	20	0	100.0%	0	0	0
Cattail	PC	19	20	39	3	92.3%	2 / 1	0	0
Dogbane	PC	4	20	24	0	100.0%	0	0	0
Milkweed	PC	19	19	38	2	94.7%	0	0	2
Threesquare Bulrush	PC	20	22	42	4	90.5%	2 / 2	0	0
Seepweed	PC	3	5	8	0	100.0%	0	0	0
Disturbed Herbaceous*	PC	0	19	19	0	100.0%	0	0	0
Open Water / Submerged Aquatic Vegetation (SAV)	PC	20	20	40	0	100.0%	0	0	0
Infrastructure	PC	0	11	11	0	100.0%	0	0	0
Playa	PC	19	20	39	0	100.0%	0	0	0
Barren Rockface	PC	4	0	4	0	100.0%	0	0	0

***These 2 PCs were split post accuracy assessment**. The resulting PCs were as follows: (1) Disturbed Herbaceous; (2) *Halogeton glomeratus* Semi-natural Herbaceous Vegetation Alliance (B.009) and *Chrysothamnus albidus* Shrubland Alliance (A.834), and *Ericameria nauseosa* Shrubland Alliance (A.835).